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Metals Control Efficiency Test at a Dry Scrubber and Baghouse Equipped Hazardous Waste Incinerator

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EPA

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U.S. Environmental Protection Agency
Office of Solid Waste
Waste Treatment Branch
401 M Street, SW
Washington, D.C. 20460

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The EPA, OSW is developing regulations to control emissions of toxic metals from hazardous waste incinerators. As part of an effort to gather data on control efficiencies that can be achieved by hazardous waste incineration facilities, equipped with various types of air pollution control devices, a test was performed at Unit No. 4 in ~~SAuget,~~ Illnois.

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SECTION 1

INTRODUCTION AND OBJECTIVES

The Environmental Protection Agency, Office of Solid Waste (EPA/OSW), is developing regulations to control emissions of toxic metals from hazardous waste incinerators. As part of an effort to gather data on control efficiencies that can be achieved by hazardous waste incineration facilities (equipped with various types of air pollution control devices [APCDs]), a test was performed at the Trade Waste Incineration (TWI) Unit No. 4 in Sauget, Illinois. TWI is a division of Chemical Waste Management, Inc. (CWM).

The TWI No. 4 facility was selected for two reasons. First, it is a commercial incineration facility that receives a wide variety of solid and liquid wastes. Second, it is equipped with dual spray dryer absorbers (SDA) and fabric filters, a technology that is considered to be among the best for the control of metals emissions from municipal waste incinerators, but only scant data are available for similarly equipped hazardous waste incinerators. An additional advantage was that TWI was planning to measure stack emissions of metals concurrently with a trial burn for Unit No. 4 for the purpose of obtaining an operating permit. The trial burn by TWI included determination of the destruction and removal efficiency (DRE) of selected organic compounds, particulate emissions, and HCl.

The EPA test involved additional measurement of particulate and metals concentrations at the inlet to the spray dryers. In this report, the test results from EPA's inlet sampling are used with the concurrent test results of TWI's stack emissions testing to determine the toxic metals and particulate control efficiencies of the spray dryer/fabric filter system. Determination of the control efficiencies was the primary objective of the EPA test. Baghouse/spray dryer residual and spray dryer lime slurry samples collected by TWI were also analyzed for toxic metals.

Metals measured in this test program were silver (Ag), arsenic (As), barium (Ba), beryllium (Be), cadmium (Cd), chromium (Cr), mercury (Hg), lead (Pb), antimony (Sb), and thallium (Tl). The first nine metals were spiked into the solid waste feeds by TWI to ensure detectable quantities in the stack gases. Thallium was not added to the waste feed; this was due to its high toxicity.

Three test runs were conducted with replicate incinerator and SDA operating conditions. The test runs and dates were as follows:

Run No.	Date
1	November 16 and 17, 1989
2	November 18 and 20, 1989
3	November 21, 1989

After beginning Run 1 on November 16, sampling had to be stopped due to difficulties with a portion of the solid waste feed system. This run was resumed and completed the next day. Run 2 began on November 18, but again sampling had to be suspended, this time due to operational difficulties with the air pollution control system. This run resumed and was completed on November 20. The third run was conducted the next day, November 21. Section 4.1 provides further information on the chronology of sampling events

A typical sampling run is generally not conducted with long breaks or over multiple days, but had to be done in this case due to mitigating circumstances. QA/QC measures were taken to ensure that sampling as completed was representative of actual conditions. The sampling trains were securely stored and checked for deterioration of the permanganate solution. Also, an effort was made to duplicate facility operating conditions as closely as possible when testing was resumed the next day.

The subsequent sections of this report present results for the trial burn as follows:

Section 2--Process Description
Section 3--Sampling and Analysis Procedures

Section 4--Discussion of Results
Section 5--QA Results

Appendices:

Appendix A--Description of Sampling and Analysis Procedures
Appendix B--Example Calculations
Appendix C--Process and Waste Feed Rate Data
Appendix D--Method 5 for Metals Calculations
Appendix E--Analytical Results for Cl, Ash, HHV, Density, and Viscosity
Appendix F--Metals Analysis Results
Appendix G--Modifications to EPA Draft Metals Protocol and EPA SW-846
Appendix H--Field Data Sheets
Appendix I--Calibration Data for Sampling Equipment

SECTION 2

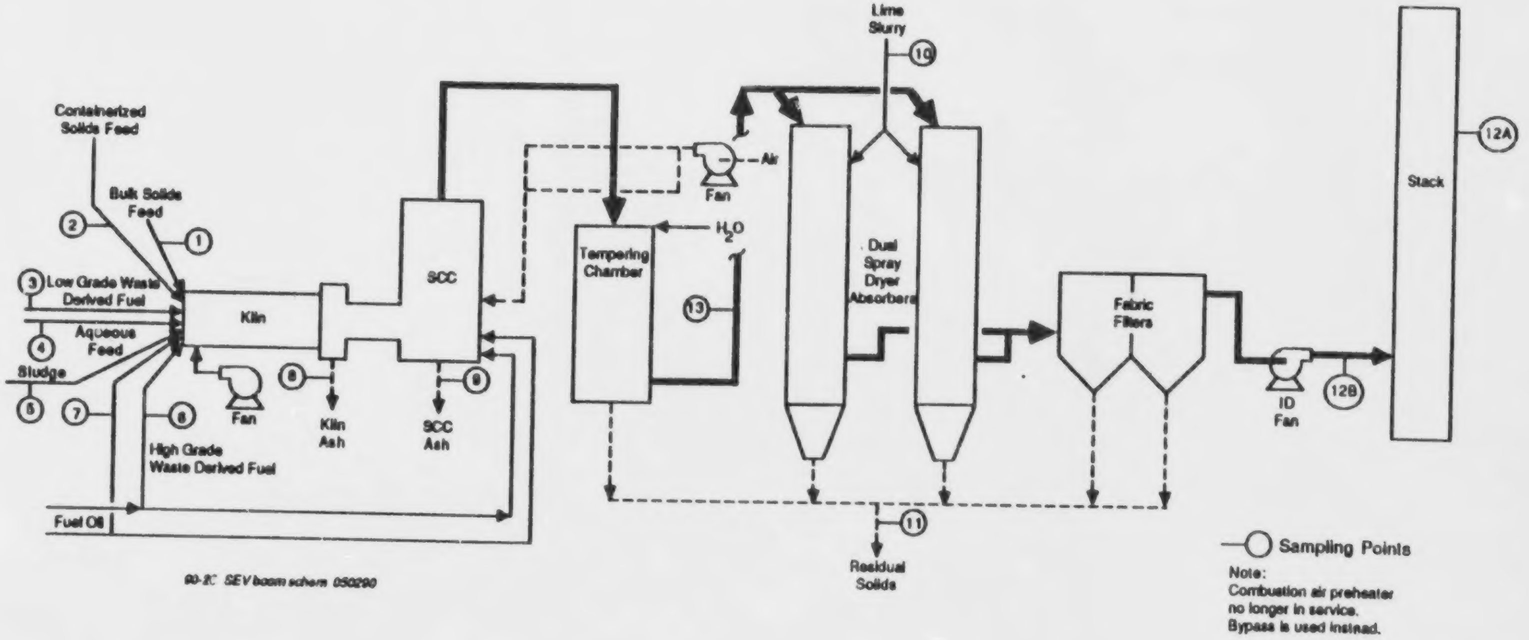
FACILITY DESCRIPTION

TWI Unit No. 4 is a rotary kiln incinerator (RKI). It is a Py*Rox Model 250 Transportable Incinerator with the major components arranged (in series) in three sections or trains. These are the front end feed train, the combustion/incineration train, and the air pollution control train (see Figure 2-1). The circled numbers on Figure 2-1 show sampling locations referred to in Section 3. Table 2-1 provides a listing of design specifications for this incinerator.

The remainder of this section presents descriptions of the facility components.

2.1 FRONT END FEED TRAIN

The front end feed train takes appropriate bulk solid wastes through weigh hoppers into the rotary kiln via either a hydraulic ram or an auger feed unit. Wastes, containerized in plastic or fiber drums, are fed into the kiln through a hydraulically actuated side port on the ram feeder unit. Nozzles and burners on the faceplate of the kiln provide injection points for various pumpable waste streams.


Containerized Solids Feed
Bulk Solids Feed
1
2
3
Low Grade Waste Derived Fuel
4
Aqueous Feed
Sludge
5
7
6
High Grade Waste Derived Fuel
Fuel Oil
Kiln
Fan
8
Kiln Ash
SCC
9
SCC Ash
Tempering Chamber
H_2O
13
Fan
Air
Lime Slurry
10
Dual Spray Dryer Absorbers
11
Residual Solids
Fabric Filters
ID Fan
12B
Stack
12A
Sampling Points
90-2C SEV boom schem 050290

Note:
Combustion air preheater
no longer in service.
Bypass is used instead.

Figure 2-1. Schematic diagram of Unit No. 4.

TABLE 2-1. DESCRIPTION OF TWI-RKI UNIT NO. 4 INCINERATOR, SAUGET, ILLINOIS

Model No.:	PY*ROX
Design:	International Waste Energy Systems (IWES)
Type of Incinerator:	Transportable Rotary Kiln
Feed Types:	Bulk and drummed solids, organic liquids, aqueous liquids, and wet solids (sludge)
Heat Release Rating:	50 million Btu/h total 25 million Btu/h primary combustion chamber (kiln) 30 million Btu/h secondary combustion chamber (SCC)

Dimensions:

	Kiln (ft)	Secondary combustion chamber (ft)
External length:	35	71
External diameter:	8	10.5
Internal diameter:	7	9

Liquid waste injectors: Dual fluid nozzles rated at 0-750 gpm (kiln only)

Burners:

	Kiln main burner (1)	Secondary combustion chamber main burner (2)	Secondary combustion chamber pilot burners (1)
Manufacturer:	North American	T-Thermal	T-Thermal
Size:	25 million Btu/h	30 million Btu/h	2 million Btu/h
Fuel:	No. 2 fuel oil natural gas Waste derived fuel	No. 2 fuel oil natural gas Waste derived fuel	No. 2 fuel oil natural gas

Prime mover: Induced draft fan 53,000 acfm.

2.2 COMBUSTION/INCINERATION TRAIN

The combustion/incineration train is composed of an inclined, refractory-lined rotary kiln, a refractory-lined transition chamber, a hot ash conveyor, a vertical, refractory-lined secondary combustion chamber (SCC), and a slag-tap conveyor.

2.2.1 Kiln

The heart of the system is the rotary kiln which is designed to operate between 1300° and 2000°F. All of the nonliquid wastes, the aqueous wastes, and some of the liquid organic wastes are combusted in the kiln.

The rotary kiln faceplate is provided with a variable flame length burner equipped with air atomization and combustion air nozzles. Other nozzles found on the faceplate include those for sludges, aqueous wastes, organic wastes, and turbulence air. The kiln is designed to operate at a maximum heat release of 25 x 10^6 Btu/h.

2.2.2 Transition Chamber

The noncombustible residue falls via gravity through the refractory-lined transition chamber to the hot ash conveyor. The transition chamber is designed to decrease the kiln discharge gas velocity so as to reduce the carryover of particulate material into the SCC.

2.2.3 Hot Ash Conveyor

The hot ash conveyor is of the metallic pan type. The inert ash residues are carried up the conveyor past three controllable water spray nozzles where the temperature is reduced prior to discharge into roll-off boxes.

2.2.4 Secondary Combustion Chamber (SCC)

The SCC is a vertical, refractory-lined afterburner with one ambient air burner, one preheated air burner, and one pilot burner. It is designed to operate between 1800° and 2400°F. The ambient and preheated air burners are designed to release a maximum of 30 x 10^6 Btu/h. The pilot burner is designed for a heat release of 2 x 10^6 Btu/h. A thermal relief vent located at the top of the chamber protects the air pollution control train if a power failure, induced draft fan failure, low tempering chamber cooling water pressure, or high temperature at the outlet of the spray dryer absorbers should occur.

2.2.5 Slag Tap Conveyor

As nonorganic particulates are carried over from the kiln and further heated in the SCC, they pass through their fusion point. At the fusion point this material becomes molten and tends to agglomerate to form slag. The slag tends to collect on sides of the SCC and will run down the walls to the bottom. At the base of the SCC, a slag tap conveyor collects, quenches, and transports this slag to a dumpster box.

2.3 AIR POLLUTION CONTROL TRAIN

The air pollution control (APC) train consists of a tempering chamber, spray dryer absorbers (SDAs), fabric filters, and associated equipment.

2.3.1 Tempering Chamber

The tempering chamber is a refractory-lined, vertical vessel equipped with water spray nozzles. Downflow combustion gases are cooled by water from the spray nozzles to a set temperature under 1200°F. A temperature controller in the tempering chamber outlet controls the amount of water sprayed into the tempering chamber. The gases then travel laterally and then upwardly through insulated duct work to a pair of vertical spray dryer absorbers.

The abrupt change in direction of the combustion gases causes additional solid particulates to drop out of the gas stream into the bottom of the tempering chamber. These solids are collected via a double flap valve and conveyor system at the base of the tempering chamber.

2.3.2 Spray Dryer Absorbers (SDAs)

The spray dryer absorbers are insulated, vertical vessels equipped with overhead spray nozzles for the addition of lime slurry to the gas stream. The lime slurry droplets react with the acid gases to form dry calcium salts. Most of the calcium salts and excess lime are carried by the gas stream to the fabric filters. Some of the salts and lime are removed via a double flap valve and conveyor system at the base of the spray dryer absorbers.

2.3.3 Lime Slurry System

The lime slurry system consists of a dry lime bin, a lime slurry mixing tank, and pumps. The lime/water blending is a semibatch process controlled via level and density instrumentation. The lime slurry is diluted and delivered as needed to the spray nozzles in the spray dryer absorbers. The temperature of the gases exiting the SDAs is controlled by varying the amount of diluted lime slurry sprayed into the SDAs.

2.3.4 Fabric Filters

The fabric filters are pulse-jet type baghouses with isolatable compartments for on-stream maintenance. The particulate which is carried over from the spray dryer absorbers will coat the exterior of the individual filter bags. Periodically, an internal header directs a blast of air downwardly inside of these bags. This blast causes the bag to flex, dislodging the built-up filter cake. Filtered material drops to the bottom collecting chambers, and collecting conveyors receive this material and transport it to a vacuum truck for disposal.

2.3.5 Collecting Drag Conveyors

The collecting drag conveyors transport collected particulates, calcium salts, and unreacted lime from the spray dryer absorbers, tempering chamber, and the fabric filters to a dense airveying system which will discharge the material into a vacuum tanker. The material and air from this system will discharge to a collecting baghouse which discharges to the vacuum tanker. The air then passes through the bulk solids storage baghouse prior to discharging to the atmosphere.

2.3.6 Induced Draft Fan

The induced draft fan provides the motive power for the entire incinerator train and APC train (combustion gas flow). In so doing, the fan produces a systemwide negative pressure to prevent fugitive emissions.

SECTION 3

SAMPLING AND ANALYSIS PROCEDURES

The sampling and analysis methods required to determine the control efficiency of toxic metals and particulate in the spray dryer/fabric filter system are listed in Table 3-1. The analyses for all samples were performed on a Jarrell-Ash Model 1155A inductively coupled argon plasma atomic emission spectrometer (ICP-AES), a Perkin-Elmer Model 5000 Zerman graphite furnace atomic absorption spectrometer, a Perkin-Elmer Model 3030B atomic absorption spectrometer, and a GBC Model 902 cold vapor atomic absorption spectrometer. The following sections present the sampling and analytical methods used for each sample listed in Table 3-1.

3.1 WASTE FEEDS

The waste feed streams to the incinerator consisted of high grade liquid organic waste, aqueous waste, containerized solids, and bulk solids. The organic liquid and aqueous feeds were sampled every 15 min during the test burn, and a run composite of each was made. Grab samples from every other bulk containerized solids drum were composited into a single sample for each run. Bulk solids were sampled in much the same way as containerized solids, except that composites of several grab samples (at least 12 each) were taken from the material in the bulk storage bin that was used in each run. The metals input rate to the incinerator was supplemented by adding a polyethylene bottle containing metals salts to every fifth containerized drum. These bottles were not sampled as part of the drum sampling.

The bulk solid waste and containerized solid waste samples were prepared for analysis by acid digestion with nitric acid and hydrogen peroxide

TABLE 3-1. TEST PROTOCOL FOR METALS

Sample	Sampling frequency for each run	Sampling method	Sample size	Analytical parameters	Preparation method	Analytical method
Containerized solid waste	One grab sample every other solid charge, composited at end of test	Scoop (S007)	~ 250 g per grab	Metals[c]	Acid digestion (SW-846-3050)	ICP (SW-846-6010), GFAA (SW-846-7000 series) and CVAA (SW-846-7470-7471) as needed
Bulk solid waste	Composite several subsamples (~ 12) of solids in bulk bin(s) used in each run	Scoop (S007)	~ 250 g per grab	Metals[c]	Acid digestion (SW-846-3050)	ICP (SW-846-6010), GFAA (SW-846-7000 series) and CVAA (SW-846-7470-7471) as needed
Baghouse and spray dryer absorber residual[a]	One grab sample per run	Scoop (S002)	~ 500 g per grab	Metals[c]	Acid digestion	ICP (SW-846-6010), GFAA (SW-846-7000 series), and CVAA (SW-846-7470-7471) as needed
Lime slurry[a]	One grab sample per run	Tap (S004)	~ 500 g per grab	Metals[c]	Acid digestion	ICP (SW-846-6010), GFAA (SW-846-7000 series), and CVAA (SW-846-7470-7471) as needed

(continued)

TABLE 3-1 (continued)

Sample	Sampling frequency for each run	Sampling method	Sample size	Analytical parameters	Preparation method	Analytical method
Stack gas	2-h composite per run	Multiple metals sampling train	60-100 ft^3[b]	Metals[c]	Acid digestion	ICP (SW-846-6010), GFAA (SW-846-7000 series) and CVAA (SW-846-7470-7471) as needed
				Particulate	Desiccation	Gravimetric
SDA inlet	2-h composite per run	Multiple metals sampling train	60-100 ft^3[b]	Metals[c]	Acid digestion	ICP (SW-846-6010), GFAA (SW-846-7000 series) and CVAA (SW-846-7470-7471) as needed
				Particulate	Desiccation	Gravimetric

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[a] EPA's test plan included metals analysis of lime slurry and baghouse and spray dryer absorber residual samples collected by TWI.

[b] Exact volume of gas sampled was dependent on isokinetic sampling rate.

[c] Metals analyzed were As, Cd, Cr, Be, Sb, Ba, Pb, Hg, Ag, and Tl.

according to the EPA SW-846 Method 3050 with modifications as listed in Appendix G. They were then analyzed to determine the concentration of 10 toxic metals (Ag, As, Ba, Cd, Cr, Hg, Pb, Sb, and Tl). Other waste feeds (e.g., high grade liquid organic) were not analyzed for metals since none was expected to be present, and analysis for metals in liquid organics is very difficult.

3.2 MULTIPLE METALS SAMPLING TRAINS

Stack gas was sampled in each of the three runs with EPA's proposed multiple metals sampling train ("Methodology for the Determination of Metals Emissions in Exhaust Gases From Hazardous Waste Incinerators and Similar Combustion Processes," 8/89) The inlet stream of the SDA was similarly sampled except that a water-cooled probe was used as part of the inlet sampling train because of the high temperature (800° to 900°F) of the inlet gas stream. The inlet sampling train contained a flexible Teflon transfer line from the probe to the sample box, due to the constraints of the sample location. The flexible transfer line was recovered in a manner similar to that used for the probe, and the wash solutions were added to the front-half train sample. The samples from both trains were analyzed for the 10 toxic metals. Samples recovered from the sampling trains were split into three groups: front-half train samples (composed of filters, acetone probe rinses, nitric acid probe rinses, and cyclone catches); back-half train samples (composed of nitric acid/hydrogen peroxide impingers and their nitric acid rinses); and permanganate impingers. The back-half train samples were prepared for analysis by initially reducing the volume by heating without boiling. The reduced volume sample was then digested with nitric acid and hydrogen peroxide according to the EPA draft method, with modifications as listed in Appendix G. The front-half train samples were prepared for analysis in two groups: inlet SDA and stack emissions trains. For both trains prior to metals analyses, the probe rinse was evaporated and filter was desiccated. The particulate loading was then determined gravimetrically. For the stack emissions trains, the acetone probe rinses were resolubilized in concentrated nitric acid, combined with the nitric acid probe rinses, reduced in volume, and combined with their respective filters. For the inlet SDA trains, the acetone probe rinses were combined with the cyclone catch and this combined sample was subsampled, prepared, and analyzed separately from the filter and nitric acid probe rinses. The permanganate impinger and portions of the back-half train and digested front-half were prepared for cold vapor mercury atomic absorption analysis by EPA SW-846 Method 7470, with modifications as listed in Appendix G.

3.3 BAGHOUSE/SPRAY DRYER ABSORBER RESIDUAL AND LIME SLURRY

The combined baghouse residual and the spray dryer absorber residual was sampled directly from the discharge conveyor during the middle of each run. The lime slurry was sampled from the slurry feed line to the SDAs. This sample was collected by the tap method (S004) into a glass sample container. One grab sample was collected during each run. These samples were prepared for metals analysis and analyzed by the same method used for the waste feeds.

SECTION 4

DISCUSSION OF RESULTS

The overall objective of this test was to provide data on metals removal efficiencies for the spray dryer/fabric filter system. As is discussed in the following sections, removal efficiencies for the spray dryer/fabric filter were generally above 99% for all the metals except thallium and mercury. Consequently, overall removal efficiencies for the incineration system were also in excess of 99%, with the exceptions noted above. The following sections discuss the test results in greater detail.

4.1 PROCESS OPERATIONS

4.1.1 Test Conditions

This section presents incinerator operating data for the three test runs. As stated in the Draft Test and QA Plan, this test was concurrent with trial burn testing performed by MRI for the facility. Metals were tested during three of the four runs during one of the operating conditions for TWI's trial burn.

Table 4-1 summarizes the operating parameters for the three runs, presented as average values calculated from readings taken in the control room every 15 min. The values for these parameters for Runs 1 and 2 represent averages over the period of sampling for the RCRA portion of the test, which did not completely correspond with the period during which the SDA inlet and outlet sampling occurred. This was due to a variation of approximately 30 min in the sampling periods between the SDA inlet and outlet trains and the other RCRA sampling trains.

TABLE 4-1. OPERATING PARAMETERS

	Run 1	Run 2	Run 3
Test date	11/16,17/89	11/18,20/89	11/21/89
Aqueous feed to kiln (lb/h)	491	501	508
Fuel oil to kiln (lb/h)	729	783	723
Drum solids to kiln (lb/h)	3,355	3,503	3,575
Bulk solids to kiln (lb/h)	14,131	13,123	12,636
Pilot fuel oil (lb/h)	83	86	87
HGWDF to SCC (lb/h)	965	992	992
Fuel oil to SCC (lb/h)	583	505	499
Kiln temperature (°F)	1431	1406	1424
SCC temperature (°F)	1955	1968	1987
Kiln pressure (inWC)	-0.79	-0.79	-0.58
SCC pressure (inWC)	-0.89	-1.00	-1.20
Stack flow (acfm)	46,000	46,370	44,920
Stack Monitors			
Oxygen (%, avg)	7.0	7.3	7.0
CO (ppm, avg)	2	2	3
THC (ppm, avg)	0	13	0
Opacity (%)	0	0	0
SDA exit temperature (°F)			
No. 1	372	383	382
No. 2	373	384	381
Lime slurry to SDA (gpm)			
No. 1	13.5	13.8	13.3
No. 2	13.4	13.3	13.1

Each run consisted of 2 h of actual sampling time, but the actual incinerator operating time was longer because of some difference in the operating interval for the different sampling trains and time for leak checks and port change.

Sampling had been scheduled to begin on November 13, 1989, but was delayed because of difficulties with the incinerator maintaining trial burn conditions, and minor operational problems associated with the SDA and the sludge feeder. Run 1 began on November 16, 1989. Testing was stopped when problems developed with the stack multiple metals sampling train and with a portion of the solids feed system. The stack sampling train was rebuilt with fresh impinger solutions and filter, and a smaller nozzle was installed on the sampling train probe. Sampling was begun again on the following day, November 17. The SDA inlet sampling train, however, was stored intact and continued sampling when outlet sampling began on November 17. During Run 2 on November 18, the plant shut down because of high HCl continuous monitor readings, and plant personnel replaced the lime slurry spray nozzles in both SDAs. Both trains resumed sampling 2 days later on November 20 when Run 2 metals sampling was continued.

A typical sampling run is generally not conducted with long breaks or over multiple days, but had to be done in this case due to mitigating circumstances. QA/QC measures were taken to ensure that sampling as completed was representative of actual conditions. The sampling trains were securely stored and checked for deterioration of the permanganate solution. Also, an effort was made to duplicate facility operating conditions as closely as possible when testing was resumed the next day.

4.1.2 Metals Spiking Procedures

The metal spiking was achieved by the addition of a bottle containing specific weights of metallic compounds to every fifth containerized solid drum. Each such bottle (~ 550 g) contained the mixture of metal salts (Ag, As, Ba, Cd, Cr, Hg, Pb, Sb, and Be) in powder form. All of the spike bottles were prepared by individually weighing each of the nine compounds. The composition of these mixtures and the equivalent metal weights are shown in

Table 4-2. Example calculations used to determine metal content and input rates are given in Appendix B. The number of metal spike containers fed in each run and the feed rate for each metal based on the metal spike are presented in Table 4-3.

4.1.3 General Waste Feed Characteristics

As part of TWI's test program, waste feed characterization for HHV, Cl, ash, etc., was performed by Galbraith Laboratories. Results of these analyses can be found in Appendix E. Table 4-4 shows the Cl input rate for each run.

4.2 PARTICULATE EMISSIONS AND EFFICIENCY

As stated previously, each run included sampling of stack emissions and SDA inlet gases. Particulate was determined at both sampling points. The stack particulate emission rate was determined by using an M5 train for particulate/HCl as part of the facility's RCRA trial burn. The SDA inlet particulate loading was determined by weighing the filter and probe rinse prior to metals analysis. The particulate results and SDA particulate removal efficiency (percent removed) are summarized below:

	SDA inlet[a] particulate (gr/dscf) corr. 7% O_2	Stack emission[b] particulate (gr/dscf) corr. 7% O_2	SDA particulate removal efficiency (%)
Run 1	3.7566	0.0087	99.77
Run 2	5.9961	0.0102	99.83
Run 3	5.6357	0.0093	99.83
Average	5.1295	0.0094	99.81

---

[a] From SDA inlet metals trains.

[b] From stack M5 train for particulate/HCl.

TABLE 4-2. COMPOSITION OF METAL SPIKE MIXTURE

Compound	Compound weight/bottle (lb)	Equivalent metal weight/bottle (lb)	Equivalent metal weight/bottle (g)	Metal
Silver nitrate	0.5	0.3	136	Ag
Arsenic trioxide	0.03	0.02	9	As
Barium sulfate	0.02	0.01	5	Ba
Beryllium sulfate tetrahydrate	0.005	0.00025	0.1	Be
Cadmium chloride	0.05	0.03	14	Cd
Chromium(III) oxide	0.08	0.05	23	Cr
Lead chloride	0.02	0.015	7	Pb
Mercury(II) sulfate	0.005	0.003	1	Hg
Antimony trioxide	0.5	0.4	181	Sb

TABLE 4-3. METAL FEED RATES BASED ON METALS SPIKE

Metal	Weight[a] per drum (lb)	Metal feed rates based on spike					
		Run 1		Run 2		Run 3	
		(lb/h)	(g/min)	(lb/h)	(g/min)	(lb/h)	(g/min)
Silver (Ag)	0.3	0.75	5.66	0.75	5.66	1.20	9.07
Arsenic (As)	0.02	0.05	0.38	0.05	0.38	0.08	0.60
Barium (Ba)	0.01	0.03	0.19	0.03	0.19	0.04	0.30
Beryllium (Be)	0.00025	0.001	0.005	0.001	0.005	0.001	0.008
Cadmium (Cd)	0.03	0.08	0.57	0.08	0.57	0.12	0.91
Chromium (Cr)	0.05	0.13	0.94	0.13	0.94	0.20	1.51
Mercury (Hg)	0.003	0.01	0.06	0.01	0.06	0.01	0.09
Lead (Pb)	0.015	0.04	0.28	0.04	0.28	0.06	0.45
Antimony (Sb)	0.4	1.00	7.55	1.00	7.55	1.60	12.08

[a] For runs 1, 2, and 3, the number of metal spike containers added to the drum solid feed was 5, 5, and 8, respectively.

TABLE 4-4. CHLORINE FEED INPUT RATE

Chlorine inputs	Run 1	Run 2	Run 3
High-grade liquid waste feed			
Feed rate (lb/h)	965	992	992
% Chlorine	10.96	11.05	9.35
Chlorine input (lb/h)	106	110	93
Aqueous waste			
Feed rate (lb/h)	491	501	508
% Chlorine	0.15	0.11	0.10
Chlorine input (lb/h)	0.74	0.55	0.51
Drum solid feed			
Feed rate (lb/h)	3,355	3,503	3,575
% Chlorine	8.20	10.98	9.92
Chlorine input (lb/h)	275	385	355
Bulk solid feed			
Feed rate (lb/h)	14,131	13,123	12,636
% Chlorine	2.75	1.16	1.65
Chlorine input (lb/h)	389	152	208
Total chlorine input (lb/h)	770	647	656
% Total chlorine	3.79	3.32	3.45

4.3 METALS EMISSIONS AND EFFICIENCY

Metals analysis results are summarized and discussed in this section. Complete analyses results for each component of the multiple metal sampling trains and the process samples (composed of bulk solids composites, drum solids composites, baghouse/spray dryer residual, lime slurries) can be found in Appendix F. The calculations used to determine the feed rate of each metal from the metals spike are included in Appendix B.

The primary purpose of this test was to evaluate the metals removal efficiency of the spray dryer/fabric filter system. Removal efficiencies for each metal in each run were calculated across the system and are displayed in Table 4-5. Removal efficiencies across the entire process are also included in Table 4-5 along with the metal flow rates in the feed, at the SDA inlet, and in the stack emissions. The discussion below summarizes the control efficiency of the toxic metals in the spray dryer/fabric filter system. Removal efficiencies were greater than 99% for all metals except for silver, thallium, and mercury. Because the metals spike did not contain thallium and the concentration of thallium in the waste feed was below the level of quantification, a removal efficiency could not be determined. For runs 2 and 3 the emission rate of mercury was measured as being greater than the spiked feed rate. This may be due to the presence of mercury in waste feeds which were not analyzed due to analytical method difficulties, or more likely, to non-representative sampling of the bulk solids. There were no analytical difficulties associated with the sample results for mercury. Also, the stack emission rates for mercury in runs 2 and 3 appeared to be greater than the SDA inlet rates. However, the values appear to be within the limits of the analytical methodology and probably reflect low control efficiency, which is consistent with mercury's volatility.

It is suspected that the determination of silver at the SDA inlet and stack emissions may have been affected by chloride collected in the sample as HCl. Due to the requirements for low level detection of lead and arsenic, it was necessary to prepare the samples for graphite furnace atomic absorption (GFAA) analysis. Sample preparation for GFAA involves digestion with nitric acid and although this procedures will solubilize silver, a potential problem

TABLE 4-5. METALS TESTING RESULTS

Metal	Feed rate (lb/h)	Feed rate (g/min)	SDA inlet rate (lb/h)	SDA inlet rate (g/min)	Stack emission rate (lb/h)	Stack emission rate (g/min)	SDA/FF removal efficiency (%)	Overall removal efficiency (%)
RUN 1								
Silver	0.749	5.66	0.100[a]	0.76[a]	b	b	b	b
Arsenic	0.132	1.00	0.049	0.37	0.00002	0.00015	99.96	99.99
Barium	0.668	5.05	0.286	2.16	0.0014	0.0107	99.50	99.79
Beryllium	0.001	0.005	0.00032	0.00242	0.000003	0.00002	99.17	99.60
Cadmium	0.082	0.62	0.107	0.811	0.00024	0.0018	99.78	99.71
Chromium	0.447	3.38	0.143	1.08	0.00074	0.0056	99.48	99.83
Mercury	0.022	0.17	0.014	0.107	0.0054	0.041	61.68	75.88
Lead	0.712	5.38	0.706	5.34	0.00081	0.0061	99.89	99.89
Antimony	0.999	7.55	0.369	2.79	< 0.004	< 0.03	> 99.18	> 99.70
Thallium	ND[c]	ND	< 0.097	< 0.7	< 0.003	< 0.02	ND	ND
RUN 2								
Silver	0.749	5.66	0.098[a]	0.74[a]	b	b	b	b
Arsenic	0.136	1.03	0.152	1.15	0.00003	0.00023	99.98	99.98
Barium	2.01	15.2	0.513	3.88	0.00075	0.00570	99.85	99.96
Beryllium	0.001	0.005	0.0025	0.019	0.000011	0.000081	99.57	98.38
Cadmium	0.082	0.62	0.116	0.879	0.00022	0.0017	99.81	99.73
Chromium	0.474	3.58	0.488	3.69	0.00435	0.0329	99.11	99.08
Mercury	0.008	0.06	0.0153	0.116	0.0218	0.165	d	d
Lead	0.807	6.10	0.80	6.05	0.0010	0.0075	99.88	99.88
Antimony	0.999	7.55	0.27	2.01	< 0.0328	< 0.2	> 87.66	> 96.72
Thallium	ND	ND	< 0.013	0.10	< 0.024	< 0.2	ND	ND
RUN 3								
Silver	1.20	9.07	0.120[a]	0.91[a]	b	b	b	b
Arsenic	0.172	1.30	0.057	0.431	0.00006	0.000426	99.90	99.97
Barium	2.116	16.0	0.377	2.85	0.0010	0.0076	99.73	99.95
Beryllium	0.001	0.008	0.00442	0.0334	0.000017	0.000126	99.62	98.42
Cadmium	0.13	0.96	0.12	0.906	0.0003	0.0021	99.77	99.78
Chromium	0.524	3.96	0.177	1.34	0.0017	0.0125	99.07	99.68
Mercury	0.01	0.09	0.014	0.109	0.0190	0.144	d	d
Lead	0.947	7.16	0.402	3.04	0.0011	0.0083	99.73	99.88
Antimony	1.598	12.08	0.389	2.94	< 0.003	< 0.02	> 99.32	> 99.83
Thallium	ND	ND	< 0.03	< 0.2	< 0.003	< 0.02	ND	ND

[a] Revised value from reanalysis of cyclone catch.

[b] Sufficient HCl may have been present in the stack emissions to prevent an accurate determination of the concentration of silver present.

[c] ND = not determined. The concentration of thallium in the waste feed and SDA inlet was below the level of quantification; therefore, a removal efficiency could not be determined.

[d] Removal efficiencies for mercury in runs 2 and 3 were calculated as negative values.

exists if trace amounts of chloride are present. Silver precipitates quite readily with chloride to form silver chloride (AgCl). When silver chloride is present, the silver contained in it is not available for analysis as the instruments detect only analytes in solution. Addition of excess hydrochloric acid with refluxing will resolubilize the AgCl as $AgCl_2^-$. This resolubilization makes the silver available for analysis by inductively coupled plasma (ICP). However, samples resulting from digestions using hydrochloric acid cannot be analyzed by GFAA for lead and arsenic due to the formation of volatile metal chlorides during analysis, which leads to inaccurate results through premature volatilization. Unfortunately for unique samples such as train samples, two splits (one for silver and the other for GFAA) cannot be taken due to uncertainty of the homogeneity of train components such as the filter.

Since a portion of the cyclone catch samples for the SDA inlet remained, these samples were reanalyzed, including treatment with concentrated HCl, to determine Ag content. The procedure and results of this reanalysis are detailed in Appendix F. The results indicate that the draft procedure for multiple metals sample analysis yielded low results for Ag for this test.

It is suspected that the low results are related to situations where the gas stream being sampled contains significant amounts of HCl (e.g., incinerators burning chlorinated wastes) leading to formation of AgCl that is difficult to solubilize for analysis. It can also be concluded that additional treatment with concentrated HCl significantly increases the amounts of silver recovered from the samples. However, the amount of concentrated HCl used in the reanalysis of these samples had not been optimized, and may not have been sufficient for effective solubilization of the Ag, as evidenced by the comparison with input rates discussed previously and by the low spike recovery of 44%.

Use of the HCl for recovery of Ag presents the complication of precluding analysis for some other metals by GFAA (e.g., Pb and As). HCl forms volatile chlorides of Pb and As that would not be detected in the GFAA analysis. Splitting of samples for analysis is possible, but would be difficult, since the samples are solids (normally on the MM5 filter) and the initial digest solution contains undissolved solids including AgCl.

In summary, these results indicate that further development work is needed on the analysis procedure for MM5 samples, to provide accurate results for Ag, especially when the gas stream contains HCl.

Table 4-6 shows the total weights of each metal found in the blank train and sampling trains. The blank values as shown have not been subtracted from the sample values, but are provided for comparative purposes. For the SDA inlet train, blank values were much smaller than sample values for all metals. For the stack samples, however, several of the blank values are close enough to the corresponding sample value to be of note. In the case of chromium, sample values range from 17 µg in run 1 to 98.1 µg in run 2, with a blank value of 9.5 µg. A blank value at this level could mean that the true value is less than reported, and that the reported removal efficiency for this metal is actually higher than stated in Table 4-5. This may also be the case to a lesser extent for arsenic and lead. For the case of barium, the blank value is nearly the same as the reported value, leading to the conclusion that the actual value for barium could range between zero and the reported value. This is also the case for beryllium. Antimony and thallium were not detected or below the detection limit in the blank and the train sample.

In order to evaluate the fate and transport of metals during the process, the baghouse/spray dryer residual and spray dryer lime slurry samples collected by the facility were analyzed for the 10 toxic metals. Results of these analyses are given in Appendix F. The flow rate of each metal in the lime slurry is compared to that at the SDA gas inlet in Table 4-7. For all metals except mercury in Run 1, the flow rate in the SDA gas inlet stream is significantly higher than that of the lime slurry. The high contribution of mercury by the lime slurry relative to the SDA inlet gas in Run 1 prevents interpreting efficiency as removal of only mercury from the combustion of waste. The flow rate of metals in the baghouse/spray dryer residual is also shown in Table 4-7. The method used to determine the baghouse/spray dryer residual output rate is outlined in Appendix B. Caution should be used in

TABLE 4-6. WEIGHT OF EACH METAL FOUND IN THE BLANK TRAIN AND SAMPLING TRAINS

(all units μg)

	Ag	As	Ba	Be	Cd	Cr	Hg	Pb	Sb	Tl
Run 1										
SDA inlet	4,180[a]	2,091	12,175	136	4,570	6,070	3,603	30,100	15,720	< 4,200
Stack	b	0.45	31.9	0.05	5.3	17	122	18	< 70	< 50
Run 2[c]										
SDA inlet	3,300[a]	5,600	18,900	91	4,280	18,000	2,567	29,400	9,800	500
Stack	b	0.67	17.1	0.24	5.0	98.1	492	23	< 740	< 530
Run 3										
SDA inlet	4,800[a]	2,310	15,200	178	4,830	7,180	2,584	16,200	15,700	< 1,220
Stack	b	1.30	23.4	0.39	6.5	38.1	439	26	< 70	< 50
Blank train		0.3	20.8	< 0.24	1	9.5	2	5.4	< 70	< 60

[a] Value from reanalysis of cyclone catch.

[b] Sufficient HCl may have been present in the stack emission to prevent an accurate determination of the concentration of silver present.

[c] High detection limits in Run 2 were caused by additional dilutions performed during analysis. These dilutions eliminated spectral interferences observed during initial analysis trials.

TABLE 4-7. LIME SLURRY AND BAGHOUSE/SDA RESIDUAL METALS RATES
(all units g/min)

Metal	Run 1			Run 2			Run 3		
	SDA inlet rate	Lime slurry input rate	Baghouse/ SDA residual effluent rate	SDA inlet rate	Lime slurry input rate	Baghouse/ SDA residual effluent rate	SDA inlet rate	Lim slurry input rate	Baghouse/ SDA residual effluent rate
Ag	0.76[c]	b	a	0.74[c]	b	a	0.91[c]	b	a
As	0.37	< 0.006	0.086	1.15	0.007	0.33	0.431	0.01	0.32
Ba	2.16	< 0.17	0.48	3.88	0.13	0.75	2.85	0.13	1.1
Be	0.00242	< 0.007	< 0.06	0.019	< 0.006	< 0.006	< 0.0334	0.006	0.021
Cd	0.811	< 0.05	0.16	0.879	0.05	0.31	0.96	0.05	0.29
Cr	1.08	< 0.5	0.72	3.69	0.6	1.2	1.34	0.7	0.96
Hg	0.107	0.1	0.06	0.116	< 0.04	0.026	0.109	< 0.03	0.02
Pb	5.34	< 0.02	2.0	6.05	< 0.02	5.4	3.04	0.01	3.6
Sb	2.79	< 2	< 6	2.01	< 2	< 9	2.94	< 2	< 5
Tl	< 0.7	< 2	< 6	0.10	< 2	< 6	< 0.2	< 2	< 5

[a] High HCl level prevented an accurate determination for silver at the SDA inlet and in residual.

[b] Sufficient HCl may have been present in the lime slurry to prevent an accurate determination of the concentration of the silver present.

[c] Value from reanalysis of cyclone catch.

attempting to perform a mass balance using the metal flow rates found in Table 4-6. Since single grab samples of lime slurry and baghouse/spray dryer residual were taken for each run, these samples may not be representative.

SECTION 5

QUALITY CONTROL RESULTS

For quality control (QC) purposes, the analytical work included determination of the limit of quantification (LOQ) and analysis of several samples containing known quantities of metals. In this section, each of these aspects of analysis will be discussed.

The LOQ for the analysis of the solid waste feeds (bulk and containerized) and the multiple metals sampling train samples was determined for each metal by five replicate analyses of the lowest concentration standard for the GFAA and CVAA methods and by five replicate analyses of the calibration blank for the ICP method. The LOQ varied for different samples. There are two causes for this variance which are inherent to metal analysis. The first cause is that different samples typically have different initial sample weights. Second, some samples may have had additional dilutions performed during analysis in order to eliminate possible chemical and spectral interferences which were observed during initial analysis trials.

Other QC procedures performed consisted of duplicate analysis of waste feeds with analysis of spiked samples to determine recovery, analysis of NBS standards, and analysis of spiked reagent blanks. Results of these determinations are presented below.

Portions of the process samples from Run 2 were spiked, digested, and analyzed. Results from these analyses, the spiking level, and the percent recovery of the spiked metal in the matrix sample are given in Table 5-1. Of the 50 spike results, 26 were in the range from 80% to 120% recovery. Eleven other spike recoveries were not calculated due to spiking below the quantitation level, being spiked at less than 50% of the native level, or large

TABLE 5-1. RUN 2 WASTE FEED MATRIX SPIKE RESULTS

	Units	Ag	As	Ba	Be	Cd	Cr	Hg	Pb	Sb	Tl
Containerized solids											
Conc. before spike	ug/g	< 30	4.89	42.6	< 0.2	2	26	< 0.8	55.7	< 300	< 200
Conc. with spike	ug/g	44.8	8.40	73.9	2.94	42.1	60.5	36.7	76.2	< 200	< 200
Spike level	ug/g	35.5	3.30	35.5	3.30	35.5	35.5	35.5	35.5	35.5	35.5
% Recovery		126%	106%	88%	89%	114%	100%	103%	58%	NC	NC
Bulk solids											
Conc. before spike	ug/g	< 20	5.39	151	< 0.1	< 0.8	19	< 0.6	41.3	< 300	< 200
Conc. with spike	ug/g	38.2	36.9	267	1.75	3.37	64.6	26.4	77.9	< 300	< 200
Spike level	ug/g	27.7	27.7	27.7	2.60	2.60	27.7	27.7	27.7	27.7	27.7
% Recovery		138%	114%	a	67%	129%	165%	95%	132%	NC	NC
Bulk solids dup.											
Conc. before spike	ug/g	< 20	5.05	36.7	< 0.2	0.9	22	< 0.6	46.3	< 300	< 200
Conc. with spike	ug/g	44.7	36.9	70.3	2.66	40.7	69.0	34.8	81.5	< 300	< 200
Spike level	ug/g	34.7	34.7	34.7	3.26	34.7	34.7	34.7	34.7	34.7	34.7
% Recovery		129%	92%	97%	82%	117%	135%	100%	102%	NC	NC

NC = Not calculated because amount spiked was below detection level. The samples were spiked at a level above the detection level, but subsequent dilutions to eliminate interference caused the spike concentration to fall below the detection level.

[a] Due to the high concentration of barium in the sample, the spike was not at a sufficient level to adequately test recovery from the matrix.

disparity in the duplicate results, making the spike recovery artificially high or low. Ideally, spikes should be between 0.5 and 10 times the sample content, or 10 times the quantitation limit, whichever is greater. All spikes below the quantitation level were for antimony and thallium, for which the samples had to be significantly diluted to overcome interference effects in the ICP. Of the 13 spike recoveries which did not occur in the range from 80% to 120%, 5 spike recoveries for silver and one for antimony were greater than 120% and all of these were less than 10 times the quantitation limit, again due to the needed dilution of the samples to overcome interferences in the ICP. Of the remaining seven spike recoveries, five were greater than 120% and two less than 80%.

Spikes were prepared for the mercury analyses of the train samples. Spikes were prepared on impinger contents and on the digestates of the front-half-samples. The results from these analyses, the spiking level, and the percent recovery of the spiked mercury for each component of the train are given in Table 5-2. The data quality objective of 80% to 120% recovery was met except for the stack sampling train back half, which had a slightly high percent recovery of 135%.

Metals analyses of NBS standard reference material filter sets (2676C and 2677) and two laboratory prepared train blanks were also performed. The NBS standards results are shown in Table 5-3. The percent recoveries were calculated and fall within the data quality objectives except for arsenic, which was consistently high. Laboratory prepared train blanks, corresponding to the solutions and volumes used in the actual sampling trains, were analyzed for metals. These blanks were spiked at a low level and a high level. Analysis results of these spiked blanks are given in Table 5-4. The data quality objective was generally met, with the exception of the low spike for chromium in the front half, with a recovery of 192%.

TABLE 5-2. RUN 2 SAMPLING TRAIN MATRIX SPIKE RESULTS FOR HG

	Units	Stack emissions train component		
		Filter and front half	Back half	$KMnO_4$ impinger
Amount before spike	μg	2.0	480	9.8
Amount with spike	μg	11.8	830	37.8
Spike level	μg	10.5	260	28.0
% Recovery		94%	135%	100%

	Units	SDA inlet train component			
		Cyclone catch and rinses	Filter and front half	Back half	$KMnO_4$ impinger
Amount before spike	μg	175	7.90	400	< 10
Amount with spike	μg	528	17.7	655	66.6
Spike level	μg	370	9.73	279	66.4
% Recovery		96	101	91	100

TABLE 5-3. RESULTS FOR ANALYSIS OF NBS STANDARDS

NBS standard sample	Units	Ag	As	Ba	Be	Cd	Cr	Hg	Pb	Sb	Tl
NBS 2676c Ic											
Measured	ug	< 6	-	< 0.4	< 0.03	1.18	< 3	-	7.52	< 30	< 30
Certified value	ug	-	-	-	-	0.954	-	-	7.47	-	-
% Recovery		-	-	-	-	124%	-	-	101%	-	-
NBS 2676c IIc											
Measured	ug	< 6	-	< 0.4	< 0.4	3.10	< 3	-	16.28	< 30	< 30
Certified value	ug	-	-	-	-	2.83	-	-	14.92	-	-
% Recovery		-	-	-	-	109%	-	-	109%	-	-
NBS 2676c IIIc											
Measured	ug	< 6	-	< 0.4	< 0.03	10.97	< 3	-	32.55	< 30	< 30
Certified value	ug	-	-	-	-	10.09	-	-	29.81	-	-
% Recovery		-	-	-	-	109%	-	-	109%	-	-
NBS 2676c blank											
Measured	ug	< 6	-	< 0.4	< 0.04	< 0.7	< 3	-	< 0.3	< 30	< 30
Certified value	ug	-	-	-	-	< 0.01	-	-	< 0.01	-	-
NBS 2677I											
Measured	ug	< 6	0.252	< 0.3	0.047	< 0.6	< 3	-	-	< 30	< 30
Certified value	ug	-	0.103	-	0.052	-	-	-	-	-	-
% Recovery		-	244%	-	91%	-	-	-	-	-	-
NBS 2677 II											
Measured	ug	< 6	1.45	< 0.4	0.274	< 0.7	< 3	-	-	< 30	< 30
Certified value	ug	-	1.07	-	0.256	-	-	-	-	-	-
% Recovery		-	136%	-	107%	-	-	-	-	-	-
NBS 2677 III											
Measured	ug	< 6	12.51	< 0.4	1.11	< 0.7	< 3	-	-	< 30	< 30
Certified value	ug	-	10.50	-	1.03	-	-	-	-	-	-
% Recovery		-	119%	-	108%	-	-	-	-	-	-
NBS 2677 blank											
Measured	ug	< 6	< 0.1	< 0.4	< 0.04	< 0.7	< 3	-	-	< 30	< 30
Certified value	ug	-	< 0.002	-	< 0.001	-	-	-	-	-	-

Dashes indicate that the NBS standard did not contain the metal, and therefore a certified value and % recovery are not applicable.

TABLE 5-4. ANALYSES FOR METAL SPIKES INTO LABORATORY PREPARED TRAIN BLANK SAMPLES

	Units	Ag	As	Ba	Be	Cd	Cr	Hg	Pb	Sb	Tl
Front half											
Blank											
Measured	ug	< 7	0.31	4.77	< 0.04	< 0.8	6	< 0.6	2.29	< 40	< 30
Low spike											
Measured	ug	< 6	2.58	7.20	2.40	2.44	11	–[b]	5.44	< 30	< 30
Spike	ug	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
% Recovery		NC	91%	97%	96%	97%	192%	NA	126%	NC	NC
High spike											
Measured	ug	< 7	33.2	29.7	22.9	22.9	32.8	16.7	36.4	< 40	< 30
Spike	ug	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
% Recovery		–[a]	131%	100%	92%	92%	106%	67%	136%	NC	NC
Back half											
Blank											
Measured	ug	< 20	< 0.09	< 0.6	< 0.09	< 0.7	< 6	< 2	1.00	< 30	< 30
Low spike											
Measured	ug	< 20	2.37	2.73	2.22	2.23	< 6	< 2	3.94	< 30	< 30
Spike	ug	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
% Recovery		NC	95%	109%	89%	89%	NC	NC	118%	NC	NC
High spike											
Measured	ug	< 20	24.6	24.4	23.9	24.2	26.2	18.7	28.2	< 30	21.7
Spike	ug	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
% Recovery		–[a]	98%	97%	95%	97%	105%	75%	109%	NC	87%

NC = Not calculated because amount spiked was below detection level.

[a] Measured value of silver is lower than the spike value due to the presence of interfering ion in the analysis sample.

[b] Sample was inadvertently not analyzed.

Duplicates or duplicate determinations were performed for all samples from Run 2. For the process samples, 26 of 50 duplicate determinations had at least one value less than the quantitation limit and thus percent differences could not be calculated. Of the remaining 24 determinations, 16 had values which were less than 20% different, including 8 whose values were less than 10 times the quantitation limit. Of the 8 determinations in process samples whose differences were greater than 20%, 3 occurred on samples whose values were less than 10 times the quantitation limit. At this level, greater percent differences can be expected. Another 3% differences greater than 20% occurred on the sample sample, an FF/SDA residual ash, which was not entirely homogeneous. These results are given in Table 5-5.

Fifty duplicate determinations were also performed on the train samples. The results from these analyses are given in Table 5-6. Thirty-one of these determinations showed percent differences of 10% or less and the remaining 19 had one or both values which were less than the quantitation limit. Serial dilutions were also performed on the train samples. As can be seen Table 5-7, of the 50 comparisons, 21 of the values had one or both values less than the quantitation limit and only 2 of the remaining were greater than 20% difference. Both of these results were less than 10 times the quantitation limit, where greater percent differences can be expected.

As part of TWI's test program, waste feed samples were analyzed for HHV, Cl, ash, etc., for characterization by Galbraith Laboratories. MRI prepared blind knowns that were also submitted for organic Cl and ash analysis with the results shown in Table 5-8. The QA samples for organic Cl were prepared by mixing known amounts of tetrachloroethylene with fuel oil. Ash QA samples are difficult to prepare and no standards are available that represent the expected values and sample matrices (e.g., 5% ash in organic liquids). MRI prepared samples by adding known amounts of finely divided SiO_2 or zinc oxide in fuel oil.

TABLE 5-5. DUPLICATE SAMPLE DETERMINATIONS--RUN 2 PROCESS SAMPLES

Sample	Metal									
	Ag	As	Ba	Be	Cd	Cr	Hg	Pb	Sb	Tl
Drum solids										
µg/g	< 30	4.96	46.2	< 0.2	2	29	< 0.8	62.3	< 300	< 200
µg/g	< 30	4.82	39.0	< 0.2	2	22	< 0.8	49.2	< 200	< 200
% Difference	NA	3%	17%	NA	6%	27%	NA	24%	NA	NA
Bulk solids										
µg/g	< 20	5.51	160	< 0.1	< 0.8	19	0.7	40.1	< 300	< 200
µg/g	< 20	5.27	141	< 0.1	< 0.7	19	< 0.6	42.4	< 200	< 200
% Difference	NA	5%	13%	NA	NA	3%	NA	6%	NA	NA
Bulk solids dup.										
µg/g	< 20	4.63	36.7	< 0.2	1	22	0.7	46.5	< 300	< 200
µg/g	< 20	5.47	220	< 0.2	0.7	22	< 0.6	46.1	< 200	< 200
% Difference	NA	17%	143%	NA	53%	0%	NA	1%	NA	NA
SDA residual										
µg/g	55	9.95	18.2	< 0.2	12.3	40	< 0.9	210	< 300	< 200
µg/g	50	12.8	33.9	0.2	9.75	44	< 1	178	< 300	< 200
% Difference	9%	25%	60%	NA	23%	10%	NA	16%	NA	NA
Lime slurry										
µg/g	< 10	0.07	1.1	< 0.06	0.4	5	< 0.3	0.2	< 20	< 20
µg/g	< 9	0.05	1.0	< 0.05	0.4	5	< 0.3	< 0.2	< 20	< 20
% Difference	NA	39%	6%	NA	3%	6%	NA	NA	NA	NA

NC = not calculated.
NA = not applicable or not analyzed.

TABLE 5-6. DUPLICATE SAMPLE DETERMINATIONS--RUN 2 TRAIN SAMPLES

Sample	Element									
	Ag	As	Ba	Be	Cd	Cr	Hg	Pb	Sb	Tl
Stack train filter and rinses μg	< 7	0.68	17.2	0.22	4.9	97.8	1.9	24	< 40	< 30
μg	< 7	0.66	17.1	0.25	5.0	98.5	2.0	23	< 40	< 30
% Difference	NA	3%	0%	9%	1%	1%	2%	1%	NA	NA
Stack train HNO_3 impinger μg	< 500	< 3	< 20	< 3	< 20	< 200	497	< 6	< 700	< 500
μg	< 500	< 3	< 20	< 3	< 20	< 200	463	< 6	< 700	< 500
% Difference	NA	NA	NA	NA	NA	NA	7%	NA	NA	NA
Stack train $KMnO_4$ impinger μg	NA	NA	NA	NA	NA	NA	10	NA	NA	NA
μg	NA	NA	NA	NA	NA	NA	10	NA	NA	NA
% Difference	NA	NA	NA	NA	NA	NA	1%	NA	NA	NA
SDA inlet train dry catch and rinse μg	< 2,000	4,816	18,809	86	907	9,416	162	7,679	6,417	< 4,000
μg	< 2,000	4,846	18,866	86	894	9,415	165	7,843	6,685	< 4,000
% Difference	NA	1%	0%	0%	1%	0%	2%	2%	4%	NA
SDA inlet train filter and rinses μg	< 60	141	72.6	4.78	454	4,664	7.97	2,880	666	< 300
μg	< 60	144	71.9	4.46	448	4,595	7.82	3,171	653	< 300
% Difference	NA	2%	1%	7%	1%	2%	2%	10%	2%	NA
SDA inlet train HNO_3 impinger μg	< 200	45.2	67.6	< 0.9	185	3,665	392	800	369	< 200
μg	< 200	47.1	67.4	< 0.9	183	3,654	407	787	364	< 200
% Difference	NA	4%	1%	NA	1%	0%	4%	2%	2%	NA
SDA inlet train $KMnO_4$ impinger μg	NA	NA	NA	NA	NA	NA	< 9	NA	NA	NA
μg	NA	NA	NA	NA	NA	NA	< 10	NA	NA	NA
% Difference	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

NC = not calculated; NA = not applicable or not analyzed.

TABLE 5-7. SERIAL DILUTION RESULTS

Sample	Element Ag	As	Ba	Be	Cd	Cr	Pb	Sb	Tl
Stack train filter and rinses									
µg	< 7	0.67	17.1	0.24	5.0	98.1	23	< 40	< 30
µg	< 20	0.83	18.8	0.29	5.6	114	24	< 70	< 60
% Difference	NA	25%	10%	23%	14%	16%	2%	NA	NA
Stack train HNO_3 impinger									
µg	< 500	< 3	< 20	< 3	< 20	< 200	< 6	< 700	< 500
µg	< 800	< 5	< 30	< 5	< 40	< 300	< 20	< 2,000	< 1,000
% Difference	NA	NA	NA	NA	NA	NA	NA	NA	NA
SDA inlet train dry catch and rinse									
µg	< 2,000	NA	18,837	86	901	9,416	7,761	6,551	< 4,000
µg	< 3,000	NA	19,117	87	922	9,569	8,308	7,546	< 8,000
% Difference	NA	NA	1%	1%	2%	2%	7%	15%	NA
SDA inlet train filter and rinses									
µg	< 60	142	72.3	4.62	451	4,630	3,025	659	< 300
µg	< 200	149	73.2	4.76	465	4,756	3,138	684	< 500
% Difference	NA	5%	1%	3%	3%	3%	4%	4%	NA
SDA inlet train HNO_3 impinger									
µg	< 200	46.2	67.6	< 0.9	184	3,659	794	367	< 200
µg	< 400	54.9	69.6	< 2	187	3,741	795	< 600	< 400
% Difference	NA	19%	3%	NA	2%	2%	0%	NA	NA

NC = not calculated; NA = not applicable or not analyzed.

TABLE 5-8. HHV AND Cl BLIND KNOWNS ANALYSES RESULTS

	Ash (%)		
	True value	Reported value	Accuracy
Sample 5205	0	0.01	-
Sample 5206	2.00	1.94	97%
Sample 5207	5.00	4.56	91%
	Organic Cl (%)		
	True value	Reported value	Accuracy
Sample 5208	0	< 0.001	-
Sample 5209	4.30	4.38	102%
Sample 5210	8.50	8.69	102%

APPENDIX A

DESCRIPTION OF SAMPLING AND ANALYSIS METHODS

NOTE: This appendix contains the sampling and analysis procedures as actually used (Work Assignment No. 57). Deviations from the Draft Test and QA Plan dated November 10, 1989, procedures during the actual sampling and analysis are listed below. It should also be noted here that the metals testing was performed during Condition B of the trial burn, not Condition A as was stated in the Draft Test and QA Plan.

- A.1.1.1 Impinger 5 of the multiple metals sampling train contained 100 mL of 4% $KMnO_4$/10% H_2SO_4 instead of NaOH. This ensured collection of all mercury within the SDA inlet gas and stack emissions.

- A.1.1.1 Due to the high amount of particulate present at the SDA inlet, a cyclone was incorporated into the sampling train at this location.

- A.1.1.4 Instead of disposing of the contents of impinger 5 after weighing, it was poured into container 5 with the contents of impinger 4. It was then rinsed three times with acidified permanganate solution and three times with hydrogen peroxide solution. All rinses were added to container 5.

- A.1.3 Instead of four sampling runs, only three runs were performed because the facility chose not to conduct the fourth stack sampling run.

- A.2.1 Particulate weights were determined for both SDA inlet and stack metals trains prior to metals analysis.

- A.2.2 The cyclone catch from the SDA inlet multiple metals sampling train was prepared separately by microwave digestion with nitric and hydrofluoric acids. The samples were then analyzed following the same method described.

A.1 SAMPLING AND ANALYTICAL PROCEDURES

This section summarizes the sampling methods used for the spray dryer inlet gas stream testing.

A.1.1 MULTIPLE METALS SAMPLING TRAIN

A.1.1.1 Sampling Train Description

The train used for metals is similar to a standard EPA Method 5 train, except that it includes special solutions in the impingers to collect volatile metals (see Figure 2). The impingers are charged as listed below:

- Impinger one--Empty (2-L impinger)
- Impingers two and three--100 mL 5% HNO_3/10% H_2O_2
- Impinger four--100 mL of 4% $KMnO_4$/10% H_2SO_4
- Impinger five--100 mL of 4% $KMnO_4$/10% H_2O_2
- Impinger six--200 g of silica gel

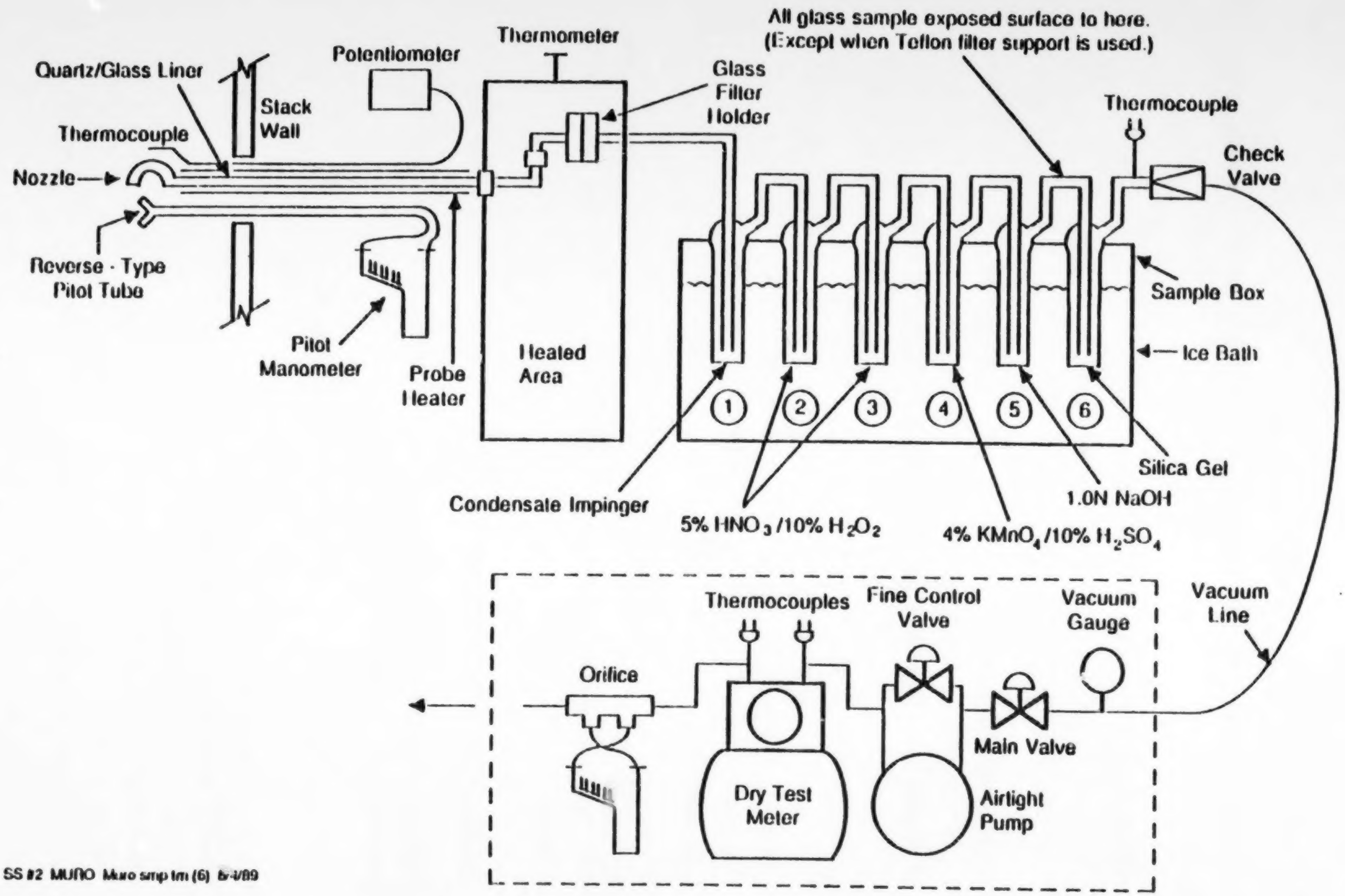
Due to the high amount of particulates present at the SDA inlet, a cyclone was incorporated into the sampling train for the SDA inlet. This cyclone is not shown in Figure 2.

A.1.1.2 Metals Train Preparation

Calibration--Components of the metals train were calibrated, checked for proper operation, and cleaned for use prior to arrival on-site.

As a minimum, the following equipment was calibrated:

1. Dry gas meter/orifice.
2. Stack temperature thermocouple.
3. Filter oven thermocouple.
4. Dial thermometers for gas meter.
5. Probe nozzles.
6. Pitot tube (by dimensional standards).


All glass sample exposed surface to here.
(Except when Teflon filter support is used.)
Thermometer
Potentiometer
Quartz/Glass Liner
Stack Wall
Thermocouple
Nozzle
Reverse - Type Pitot Tube
Pitot Manometer
Probe Heater
Heated Area
Glass Filter Holder
Thermocouple
Check Valve
Sample Box
Ice Bath
1
2
3
4
5
6
Condensate Impinger
5% HNO_3/10% H_2O_2
4% $KMnO_4$/10% H_2SO_4
1.0N NaOH
Silica Gel
Vacuum Line
Thermocouples
Fine Control Valve
Vacuum Gauge
Orifice
Dry Test Meter
Main Valve
Airtight Pump

SS #2 MURO Muro smp trn (6) 6/4/89

Figure 2. Schematic of the multiple metals sampling train.

Copies of all calibration data were placed in the project calibration data file. The calibration procedures used are as per *Quality Assurance Handbook for Air Pollution Measurement Systems: Volume III—Stationary Source Specific Methods*, U.S. EPA 600/4-77-027b. Copies of the pertinent protocols are included in Appendix A of the project QAP.

A glass probe tip was used as required for metals. All glassware were cleaned using the procedures listed below.

1. Rinse with tap water.
2. Wash with soapy (Acationox) water.
3. Rinse three times with tap water.
4. Rinse three times with distilled water.
5. Soak in 10% HNO_3 for 4 h.
6. Rinse three times with distilled water.
7. Final rinse with acetone.
8. Air dry.
9. Cover all openings with parafilm (not aluminum foil).

A.1.1.3 Sample Collection

Sample collection followed EPA Method 5 procedures including a blank train for metals analysis. This blank train will be assembled, heated for 2 h, and recovered using the same procedures as for actual sampling trains.

A.1.1.4 Sample Recovery

At the end of each test, after the final leak check, the sample train was taken to the field laboratory to recover the sample, as follows:

- Container 1--Filter. Use Teflon-coated tweezers or surgical gloves rinsed with water to recover the filter. Place the filter in the labeled glass petri dish.

- Container 2--Front-Half Rinse With Acetone. Rinse and brush the probe nozzle, probe, and all glassware up to and including the front half of the filter holder with acetone; repeat three times.

- Container 3--Front-Half Rinse With Nitric Acid. Rinse and brush the probe nozzle, probe, and all glassware up to and including the front half of the filter holder with 0.1 N nitric acid; repeat three times.

- Container 4--Impingers 1 Through 3. After weighing Impingers 1 through 3, collect the impinger condensate separately. Rinse each with 0.1 N HNO_3, and measure the final volume analysis.

- Container 5--Impingers 4 Through 6. Weigh Impingers 4 and 5. Pour all liquid from the permanganate Impingers 4 and 5 into Container 5. Rinse these impingers three times with the acidified permanganate solution, and add rinses to Container 5. Record the final total volume. Weigh the silica gel (Impinger 6) and dispose of the contents of impinger 6 properly.

A.1.2 ADDITIONAL INLET SAMPLING DETAILS

The sampling location meets the criteria for Method 5 sampling. The inlet testing was conducted in a 4-ft inner diameter insulated duct that is upstream of the flow split into the dual spray dryers. Because of the 800° to 1200°F temperature of this gas stream, a water-cooled probe was used for the inlet sampling. Due to the configuration of the sampling location, a Teflon probe liner and transfer line was used in the sampling train.

A.1.3 STACK EMISSIONS SAMPLING

Sampling of the inlet and stack was done simultaneously with exceptions as noted in Section 4, since the primary objective of the EPA test was the determination of spray dryer/fabric filter control efficiency. Three test runs were conducted at TWI, using similar methods as described for the inlet test. Analytical results, parameter monitoring results, and details on waste spiking were provided by TWI.

A.1.4 SAMPLING OF LIME SLURRY AND BAGHOUSE/SPRAY DRYER RESIDUAL

Sampling by TWI of the lime slurry and baghouse/spray dryer residual will involve one grab sample per run for each sample. Lime slurry was sampled via tap. Baghouse spray dryer residual was sampled with a scoop.

A.2 SAMPLE HANDLING AND ANALYSIS PROCEDURES

The following sections briefly describe the procedures to be used for the handling and analysis of the inlet metals samples. The same criteria are planned for the stack emission samples collected by TWI.

A.2.1 METALS SAMPLE HANDLING

The multiple metals train probe/front-half acetone wash and filter fractions for each test will be submitted for metal analysis along with the impinger samples. The filter blank was analyzed for metals. Particulate weights were determined for both SDA inlet and stack metals prior to metals analysis.

Figure 3 presents a schematic of the analytical scheme for the metals samples from the MM5-M train.

A.2.2 METALS ANALYSIS

Metals were analyzed in the lime slurry, fabric filter, inlet, and stack emission samples for the 10 metals (i.e., As, Cd, Cr, Be, Sb, Ba, Pb, Hg, Ag, Tl).

The metals analysis procedures for the stack emission samples are summarized in the previous Figure 3 and were done in accordance with the detailed procedures developed in the EPA draft method.

The lime slurry and fabric filter ash samples were prepared using EPA SW-846 (third edition) Method 3050 (with minor modifications detailed in Appendix B).

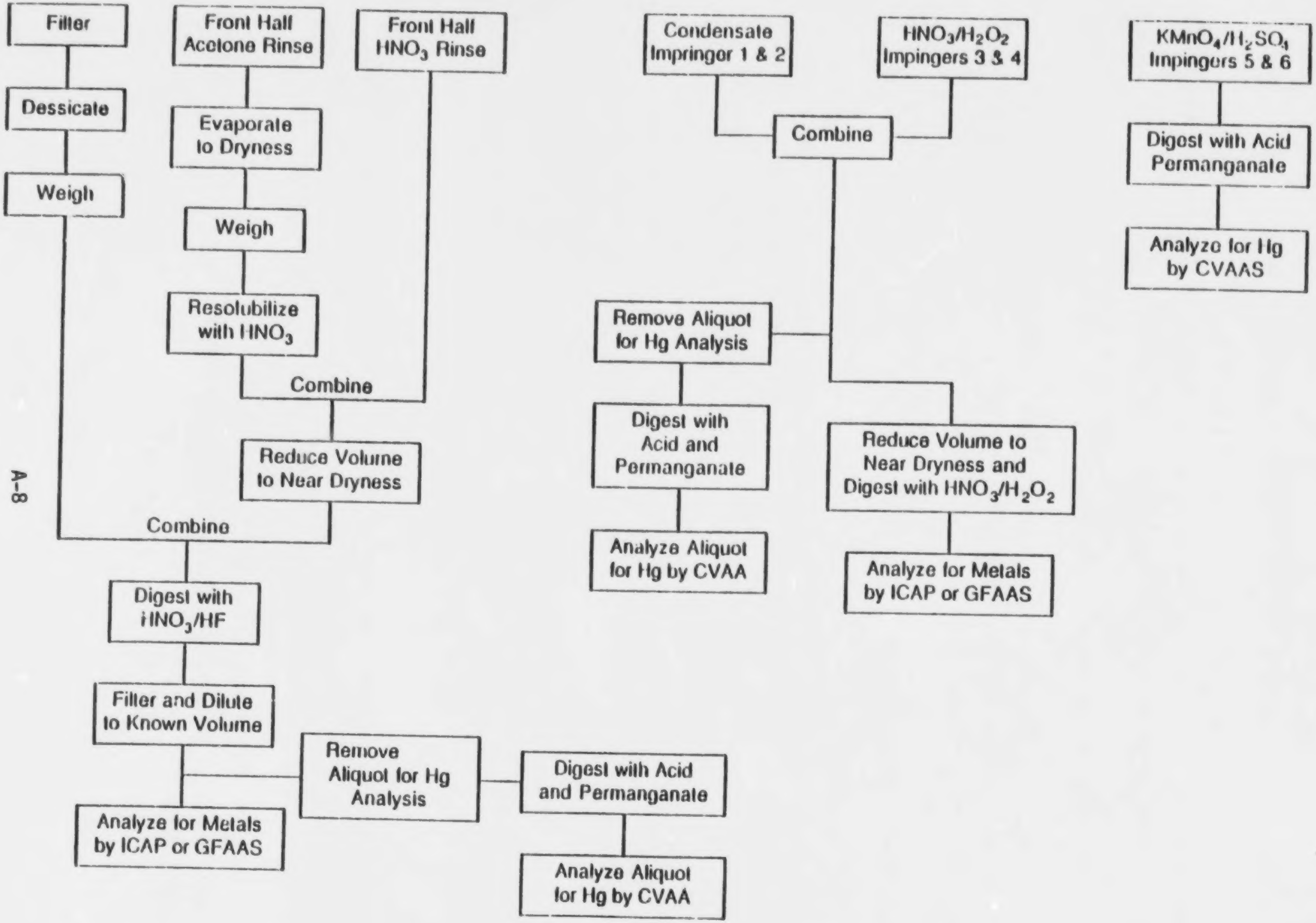

Filter
Dessicate
Weigh
Front Half Acetone Rinse
Evaporate to Dryness
Weigh
Resolubilize with HNO_3
Front Half HNO_3 Rinse
Combine
Reduce Volume to Near Dryness
Combine
Digest with HNO_3/HF
Filter and Dilute to Known Volume
Analyze for Metals by ICAP or GFAAS
Remove Aliquot for Hg Analysis
Digest with Acid and Permanganate
Analyze Aliquot for Hg by CVAA
Condensate Impringer 1 & 2
HNO_3/H_2O_2 Impingers 3 & 4
Combine
Remove Aliquot for Hg Analysis
Digest with Acid and Permanganate
Analyze Aliquot for Hg by CVAA
Reduce Volume to Near Dryness and Digest with HNO_3/H_2O_2
Analyze for Metals by ICAP or GFAAS
$KMnO_4/H_2SO_4$ Impingers 5 & 6
Digest with Acid Permanganate
Analyze for Hg by CVAAS

Figure 3. Schematic of analysis of the multiple metals train samples for metals.

Any samples which are less than 10 times the detection limit for Hg by Method 6010 will be analyzed for Hg by CVAAS Method 7470. The apparatus used is equivalent to the closed loop system diagramed in Method 7470. If any sample analyzed by Method 6010 is below 10 times the detection limit for As or Pb, it will be analyzed by the appropriate 7000 series method for As or Pb using GFAAS.

APPENDIX B

EXAMPLE CALCULATIONS

CALCULATION METHODS AND EXAMPLES

1. WASTE FEED RATES

A. Liquids

Liquid feed rates for HGWDF, aqueous, and fuel oil were determined from the feed totalizer readings (lb) taken at the beginning and end of each sampling interval and the corresponding sampling interval (h) as follows:

$$\text{Feed rate in lb/h} = \frac{\Sigma\ (\text{End totalizer reading - initial totalizer reading})}{\Sigma\ (\text{Sampling intervals in h})}$$

Data sheets containing the totalizer readings and sampling intervals are included in Appendix D.

B. Drum and Bulk Solids

The weight of each drum and bulk solid charge, and the time, are also included in Appendix D. These data were used to calculate feed rates as follows:

$$\text{Feed rate in lb/h} = \frac{\Sigma\ \text{Charge weights fed during sample in lb}}{\text{Sampling interval in h}}$$

2. Cl INPUT RATE

Chlorine input rates for each run were calculated by multiplying the feed rates for each waste (lb/h) times the % Cl for that waste feed, and adding the results together to determine the total Cl input rate in lb/h. These calculations are shown in Table 4-4 of Volume I.

3. METALS INPUT RATES FROM METALS SPIKE

The weight of each metal in the spike container was calculated from the weight of its respective metal salt as follows:

$$\text{Weight metal} = \frac{(\text{weight metal salt})(\text{molecular weight of metal})(\text{metal ratio})}{(\text{molecular weight of metal salt})}$$

where (metal ratio) = (number of moles of metal/mole metal salt).

The calculations for each metal are given in Figure B-1. The input rate was determined as follows:

$$\text{Metals in} = \frac{\begin{pmatrix}\text{Number of}\\ \text{spike}\\ \text{containers}\\ \text{fed}\end{pmatrix}\begin{pmatrix}\text{Weight}\\ \text{of metal}\\ \text{per container}\end{pmatrix}\left(\frac{453.6\text{ g}}{\text{lb}}\right)}{120\text{ min}}$$

4. METALS INPUT RATES FROM WASTE FEEDS

Input rates for each metal in each run were calculated by multiplying the feed rate for each waste (g/min) time the concentration (µg/g) of the metal in the waste. The resulting metal input rate in µg/min was converted to g/min by dividing by 1,000,000. The data results for each run are shown in Tables F-1 to F-3 of Appendix F.

$$\text{Weight Ag} = (0.5\ \text{lb AgNO}_3)\left(\frac{1\ \text{mol AgNO}_3}{169.87\ \text{lb}}\right)\left(\frac{107.87\ \text{lb}}{1\ \text{mol Ag}}\right) = 0.3\ \text{lb}$$

$$\text{Weight As} = (0.03\ \text{lb As}_2\text{O}_3)\left(\frac{1\ \text{mol As}_2\text{O}_3}{197.84\ \text{lb}}\right)\left(\frac{2\ \text{mol As}}{1\ \text{mol As}_2\text{O}_3}\right)\left(\frac{74.92\ \text{lb}}{1\ \text{mol As}}\right) = 0.02\ \text{lb}$$

$$\text{Weight Ba} = (0.02\ \text{lb BaSO}_4)\left(\frac{1\ \text{mol BaSO}_4}{233.40\ \text{lb}}\right)\left(\frac{137.34\ \text{lb}}{1\ \text{mol Ba}}\right) = 0.01\ \text{lb}$$

$$\text{Weight Be} = (0.005\ \text{lb BeSO}_4\cdot 4\text{H}_2\text{O})\left(\frac{1\ \text{mol BeSO}_4\cdot 4\text{H}_2\text{O}}{177.14\ \text{lb}}\right)\left(\frac{9.012\ \text{lb}}{1\ \text{mol Be}}\right) = 0.00025\ \text{lb}$$

$$\text{Weight Cd} = (0.05\ \text{lb CdCl}_2)\left(\frac{1\ \text{mol CdCl}_2}{182.32\ \text{lb}}\right)\left(\frac{112.41\ \text{lb}}{1\ \text{mol Cd}}\right) = 0.03\ \text{lb}$$

$$\text{Weight Cr} = (0.08\ \text{lb Cr}_2\text{O}_3)\left(\frac{1\ \text{mol Cr}_2\text{O}_3}{151.99\ \text{lb}}\right)\left(\frac{2\ \text{mol Cr}}{1\ \text{mol Cr}_2\text{O}_3}\right)\left(\frac{51.996\ \text{lb}}{1\ \text{mol Cr}}\right) = 0.05\ \text{lb}$$

$$\text{Weight Pb} = (0.02\ \text{lb PbCl}_2)\left(\frac{1\ \text{mol PbCl}_2}{278.1\ \text{lb}}\right)\left(\frac{207.2\ \text{lb}}{1\ \text{mol Pb}}\right) = 0.015\ \text{lb}$$

$$\text{Weight Hg} = (0.005\ \text{lb HgSO}_4)\left(\frac{1\ \text{mol HgSO}_4}{296.65\ \text{lb}}\right)\left(\frac{200.59\ \text{lb}}{1\ \text{mol Hg}}\right) = 0.003\ \text{lb}$$

$$\text{Weight Sb} = (0.5\ \text{lb Sb}_2\text{O}_3)\left(\frac{1\ \text{mol Sb}_2\text{O}_3}{291.50\ \text{lb}}\right)\left(\frac{2\ \text{mol Sb}}{1\ \text{mol Sb}_2\text{O}_3}\right)\left(\frac{121.75\ \text{lb}}{1\ \text{mol Sb}}\right) = 0.4\ \text{lb}$$

Figure B-1. Metal spike calculations.

5. METALS FLOW RATE AT THE SDA INLET

For each metal, the amount found in the MM5-M sample, in µg, was divided by the MM5-M sample gas volume, in dscm, and multiplied by he SDA inlet flow rate as follows (see Table F-5):

$$\frac{\left(\text{Total amount found in }\mu\text{g}\right) \times \left(\text{SDA inlet flow rate in dscm/min}\right)}{\left(\text{Total gas sample vol. in dscm}\right)\left(\frac{1{,}000{,}000\ \mu\text{g}}{\text{g}}\right)} = \text{Metal flow rate at SDA inlet in g/min}$$

6. METAL EMISSIONS

For each metal, the emission rate was calculated in the same manner as the metal flow rate at the SDA inlet. Results for the calculations as follows are given in Table F-4:

$$\frac{\left(\text{Total amount found in }\mu\text{g}\right) \times \left(\text{Stack flow rate in dscm/min}\right)}{\left(\text{Total gas sample vol. in dscm}\right)\left(\frac{1{,}000{,}000\ \mu\text{g}}{\text{g}}\right)} = \text{Metal emission in g/min}$$

7. METALS INPUT RATES IN LIME SLURRY AND OUTPUT RATES IN BAGHOUSE/SDA RESIDUAL

To determine the rate at which each toxic metal entered and exited the spray dryer absorber/baghouse systems, several calculation steps were made:

1. The 20% lime slurry density was calculated as follows:

$$\text{Density lime slurry} = \frac{1\text{ g slurry}}{\left(0.8\text{ g }H_2O\right)\left(\frac{1\text{ mL }H_2O}{1\text{ g }H_2O}\right) + \left(0.2\text{ g lime}\right)\left(\frac{1\text{ mL lime}}{3.3\text{ g lime}}\right)} = 1.16\text{ g/mL}$$

2. The input rates, via the lime slurry, for each metal in each run were calculated by multiplying the lime slurry rate (gpm) times the lime slurry density (1.16 g/mL) times the concentration (µg/g) of the metal in the lime slurry. The calculation is as follows:

$$\text{Metal input rate via lime slurry in g/min} = \frac{\left(\begin{array}{c}\text{Lime slurry}\\ \text{input rate,}\\ \text{gpm}\end{array}\right)\left(1.16\ \text{g/mL}\right)\left(\frac{3{,}785\ \text{mL}}{1\ \text{gal}}\right)\left(\begin{array}{c}\text{Metal}\\ \text{concentration,}\\ \mu\text{g/g}\end{array}\right)}{\left(\frac{1{,}000\ \mu\text{g}}{\text{g}}\right)}$$

3. It was assumed that the baghouse/SDA residual consisted primarily of the lime from the lime slurry and the particulate matter removed from the stack gas. The lime portion of the residual was calculated as follows:

$$\text{Lime output in g/min} = \left(\begin{array}{c}\text{Lime slurry}\\ \text{input rate,}\\ \text{gpm}\end{array}\right)\left(\frac{1.16\ \text{g}}{\text{mL}}\right)\left(\frac{3{,}785\ \text{mL}}{\text{gal}}\right)\left(\frac{0.2\ \text{g lime}}{\text{g of slurry}}\right)$$

The particulate rate at the SDA inlet and at the stack was obtained from the multiple metals sampling train computer-generated calculation sheets (Appendix D). The output rate of the particulate via the baghouse/SDA residual is the difference of the two values.

$$\begin{array}{c}\text{Baghouse/SDA}\\ \text{residual}\\ \text{output in}\\ \text{g/min}\end{array} = \begin{array}{c}\text{Lime output}\\ \text{in g/min}\end{array} + \left[\left(\begin{array}{c}\text{Particulate}\\ \text{rate at}\\ \text{SDA inlet,}\\ \text{kg/h}\end{array}\right) - \left(\begin{array}{c}\text{Particulate}\\ \text{emissions,}\\ \text{kg/h}\end{array}\right)\right] \times \frac{1{,}000\ \text{g/kg}}{60\ \text{min/h}}$$

4. The output rates, via the residual, for each metal in each run were calculated by multiplying the baghouse/SDA residual output rate (g/min) times the metal concentration (μg/g). The resulting metal output rate in μg/min was converted to g/min by dividing by 1×10^6.

APPENDIX C

PROCESS AND WASTE FEED RATE DATA

RUN 1 - PROCESS DATA LOG SHEET

	11/16	11/16	11/17	11/17	11/17	11/17	11/17	11/17	11/17	11/17	11/17	11/17	11/17
	17:00	17:15	11:30	11:45	12:00	12:15	12:30	13:10	13:25	13:40	13:55	14:10	14:25
Fuel oil to kiln (lb/hr) FT 109	881	855	798	766	808	730	702	720	777	750	742	717	745
Aqueous feed (lb/hr) FT 138	617	474	499	476	540	497	514	508	499	493	469	497	489
Pilot fuel oil to SCC X-16 (lb/hr) FT 231	84	84	84	83	83	84	85	85	85	85	85	86	85
HGWDF to SCC X-15 (lb/hr) FT 212	1131	1094	1013	1061	1065	1015	1041	1002	1002	1002	1002	997	1000
Fuel oil to SCC X-14 (lb/hr) FT 249	687	680	494	483	621	613	613	621	608	615	608	586	588
Kiln temperature (F)	1540	1428	NR	1418	1475	1450	1387	1497	1445	1383	1388	1443	1426
SCC temperature (F)	1921	1908	NR	1962	1967	1940	1943	1981	1962	1951	1945	1939	1958
Kiln pressure (in. WC)	-0.7	-1.40	-0.96	-0.77	-0.57	-0.76	-0.68	-0.69	-0.69	-0.95	-0.85	-0.83	-0.91
SCC pressure (in. WC)	-0.90	-1.70	-1.30	-1.00	-0.50	-0.80	-0.70	-0.80	-0.80	-1	-1	-0.9	-1
Stack flow (acfm)	46,230	47,030	41,690	43,930	46,750	47,940	47,010	46,360	46,880	45,810	47,680	46,740	45,150
O2 (%)	9.1	7.3	7.1	6.6	6.9	7.0	7.0	7.0	6.8	6.7	7.3	7.7	6.9
CO (ppm)	0	0	2	2	2	2	2	6	2	2	2	0	2
THC (ppm)	31	27	0	0	0	0	0	3	0	0	0	0	0
HCl (ppm)	20	11	11	33	8	1	1	34	3	6	11	1	2
Opacity (%)	0	0	0	0	0	0	0	0	0	0	0	0	0
SDA exit temp. (F)													
# 1	401	396	382	401	381	370	378	363	377	358	360	359	368
# 2	393	399	383	401	381	375	372	362	378	363	358	362	364
Lime slurry to SDA (gpm)													
# 1	13.9	14.4	11.6	12.9	13.7	14.1	13.4	14.3	13.8	14.2	14.7	13.3	13
# 2	13	12.2	11.5	12.8	12.7	13.1	12.8	13.8	13.6	13.7	14.7	13.9	14.3

RUN 2 – PROCESS DATA LOG SHEET

	11/18	11/18	11/20	11/20	11/20	11/20	11/20	11/20	11/20	11/20	11/20	11/20	11/20
	12:40	12:55	12:00	12:15	13:10	13:25	13:40	13:55	14:40	14:55	15:10	15:25	15:40
Fuel oil to kiln (lb/hr) FT 109	775	770	708	758	814	805	772	842	847	842	844	830	792
Aqueous feed (lb/hr) FT 138	418	666	510	486	474	534	480	553	563	510	497	504	456
Pilot fuel oil to SCC X–16 (lb/hr) FT 231	88	88	86	87	85	86	85	85	86	86	86	85	86
HGWDF to SCC X–15 (lb/hr) FT 212	1000	1000	1028	993	993	1002	1000	1000	1013	1002	1004	997	1002
Fuel oil to SCC X–14 (lb/hr) FT 249	637	604	505	525	510	507	492	512	499	503	499	514	497
Kiln temperature (F)	1453	1445	1447	1392	NR	1372	1380	1357	1389	1446	1394	1461	1424
SCC temperature (F)	2009	1997	1996	1966	NR	1924	1954	1948	1977	1988	1968	1985	1973
Kiln pressure (in. WC)	–0.62	–0.73	–0.76	–0.94	NR	–0.83	–0.76	–0.74	–0.71	–0.78	–0.88	–0.79	–0.76
SCC pressure (in. WC)	–0.7	–1.0	–1.1	–1.1	NR	–1.0	–1.3	–0.9	–1.0	–0.9	–1.1	–1.0	–1.1
Stack flow (acfm)	45,130	44,740	44,480	45,830	NR	47,120	45,800	46,180	46,180	47,130	46,080	47,000	47,930
O2 (%)	6.9	7.2	7.0	7.6	NR	7.6	7.5	7.5	7.0	7.2	7.4	6.8	6.9
CO (ppm)	2	3	NR	2	NR	2	2	2	2	2	2	2	2
THC (ppm)	0	20	NR	53	NR	61	0	0	0	0	0	0	1
HCl (ppm)	50	323	NR	21	NR	8	3	11	3	6	0	4	4
Opacity (%)	0	0	NR	0	NR	0	0	0	0	0	0	0	0
SDA exit temp. (F)													
# 1	368	417	403	390	NR	387	375	375	382	381	375	385	380
# 2	382	406	407	396	NR	393	368	382	383	379	378	380	376
Lime slurry to SDA (gpm)													
# 1	16.0	16.3	12.9	13.4	14.1	13.5	14.1	14.0	13.8	14.0	14.2	13.7	14.1
# 2	16.4	16.8	11.9	12.6	13.8	13.3	13.8	13.2	13.3	13.6	13.1	13.7	13.5

RUN 3 – PROCESS DATA LOG SHEET

	11/21	11/21	11/21	11/21	11/21	11/21	11/21	11/21	11/21	11/21
	11:35	11:50	12:05	12:20	12:35	13:20	13:35	13:50	14:05	14:20
Fuel oil to kiln (lb/hr) FT 109	634	711	705	747	733	722	819	723	802	795
Aqueous feed (lb/hr) FT 138	563	512	510	499	514	518	512	521	525	525
Pilot fuel oil to SCC X–16 (lb/hr) FT 231	88	88	88	88	88	88	87	88	88	88
HGWDF to SCC X–15 (lb/hr) FT 212	997	1011	1004	1000	1000	1006	1015	1024	1015	1011
Fuel oil to SCC X–14 (lb/hr) FT 249	492	510	505	505	521	503	514	510	505	510
Kiln temperature (F)	1500	1407	1365	1503	1388	1415	1427	1444	1372	1415
SCC temperature (F)	2030	2019	1960	1977	1958	1976	1989	1989	1979	1988
Kiln pressure (in. WC)	–0.66	–0.50	–0.54	–0.51	–0.72	–0.62	–0.55	–0.57	–0.59	–0.49
SCC pressure (in. WC)	–1.2	–0.8	–1.1	–1.0	–1.4	–1.1	–1.1	–1.3	–1.4	–1.1
Stack flow (acfm)	43,550	43,350	46,750	45,530	46,880	44,350	44,460	44,900	44,100	45,270
O2 (%)	6.9	7.2	7.4	6.1	7.5	7.6	7.2	6.9	6.4	6.8
CO (ppm)	2	2	4	3	7	2	2	2	2	2
THC (ppm)	0	0	0	0	0	0	0	0	0	0
HCl (ppm)	7	0	4	5	10	1	14	37	25	7
Opacity (%)	0	0	0	0	0	0	0	0	0	0
SDA exit temp. (F)										
# 1	380	391	384	386	387	373	379	382	376	379
# 2	378	380	386	378	383	391	375	378	382	381
Lime slurry to SDA (gpm)										
# 1	12.9	12.2	13.1	13.5	13.4	13.6	13.4	13.2	13.6	13.6
# 2	12.0	12.9	12.5	13.1	13.8	13.8	12.9	13.8	13.3	13.2

APPENDIX D

METHOD 5 DATA USED FOR METALS CALCULATIONS

TABLE D-1. MM5 SUMMARY DATA

	Sampling time (min)	Gas volume sampled (dscm)	Orsat analysis		Percent water	Average stack temperature		% Iso-kinetic	Gas flow rate			Particulate (gr/dscf) corr. 7%
			Percent oxygen	Percent carbon dioxide		(°F)	(°C)		(acfm)	(dscfm)	(dscm/min)	
Run 1												
SDA inlet	120	2.402	5.0	7.6	39.4	836	447	107.6	62,088	15,064	427	3.7566
Stack	120	1.516	11.2	7.6	38.6	347	175	98.4	45,385	17,990	509	
M5	120	1.452	11.2	7.6	39.1	349	176	110.5	48,288	18,934	536	0.0087
Run 2												
SDA inlet	120	2.091	9.6	8.8	34.7	857	458	93.1	58,389	15,154	429	5.9961
Stack	120	1.605	10.6	7.2	38.2	359	182	98.7	48,178	18,990	538	
M5	120	1.439	10.6	7.2	38.5	362	200	104.8	50,783	19,774	560	0.0102
Run 3												
SDA inlet	120	2.130	9.4	9.0	36.2	862	461	101.9	56,028	14,101	399	5.6357
Stack	120	1.679	11.4	7.2	38.6	356	180	101.0	49,207	19,412	550	
M5	120	1.396	11.4	7.2	38.7	358	181	106.0	48,328	18,974	537	0.0093

M5--Used to measure particulate and HCl emissions for facility's trial burn.

```
FILE NAME - 9102R1                                          PROG.=VER 06/27/89
RUN # - 1 - SDA MM5 METALS TRAIN                            12-11-1989  23:51:27
LOCATION - Unit 4 SDA Inlet - TWI, Sauget, IL
DATE - 11/17/89
PROJECT # - 9102-57-20

  Initial Meter Volume (Cubic Feet)=              17.659
Final Meter Volume (Cubic Feet)=                 101.865
Meter Factor=                                      0.990
Multiple leak checks, see end of printout                   Leak Correction=  0.0000
Net Meter Volume (Cubic Feet)=                    83.364
Gas Volume (Dry Standard Cubic Feet)=             84.833

Barometric Pressure (in Hg)=                       29.50
Static Pressure (Inches H2O)=                      -1.50

Percent Oxygen=                                      5.0
Percent Carbon Dioxide=                              7.6
Moisture Collected (ml)=                          1169.3
Percent Water=                                      39.4

Average Meter Temperature (F)=                        54
Average Delta H (in H2O)=                           2.00
Average Delta P (in H2O)=                          0.761
Average Stack Temperature (F)=                       836

Dry Molecular Weight=                              29.42
Wet Molecular Weight=                              24.92

Average Square Root of Delta P (in H2O)=          0.8621
% Isokinetic=                                      107.6

  Pitot Coefficient=                                0.84
Sampling Time (Minutes)=                           120.0
Nozzle Diameter (Inches)=                          0.317
Stack Axis #1 (Inches)=                             48.0
Stack Axis #2 (Inches)=                             48.0
Circular Stack
Stack Area (Square Feet)=                          12.57

Stack Velocity  (Actual, Feet/min)=                4,941
Flow Rate (Actual, Cubic ft/min)=                 62,088
Flow rate (Standard, Wet, Cubic ft/min)=          24,844
Flow Rate (Standard, Dry, Cubic ft/min)=          15,064

Particulate Loading - Front Half

Particulate Weight (g)=                          23.6502    Corr. to 7% O2 & 12% CO2
Particulate Loading, Dry Std. (gr/scf)=           4.2933         3.7566     6.7789
Particulate Loading, Actual (gr/cu ft)=           1.0412
Emission Rate (lb/hr)=                            554.26

No Back Half Analysis
```

```
                       * * METRIC UNITS * *
FILE NAME - F10ZR1                                          PROG.=VER 06/27/89
RUN # - 1 - SDA MM5 METALS TRAIN                            12-11-1989  23:51:29
LOCATION - Unit 4 SDA Inlet - TWI, Sauget, IL
DATE - 11/17/89
  PROJECT # - 9102-87-20

Initial Meter Volume (Cubic Meters)=              0.500
Final Meter Volume (Cubic Meters)=                2.884
Meter Factor=                                     0.990
Multiple leak checks, see end of printout               Leak Correction=  0.0000
Net Meter Volume (Cubic Meters)=                  2.361
Gas Volume (Dry Standard Cubic Meters)=           2.402

Barometric Pressure (mm Hg)=                        749
Static Pressure (mm H2O)=                           -38

Percent Oxygen=                                     5.0
Percent Carbon Dioxide=                             7.6
Moisture Collected (ml)=                         1169.3
Percent Water=                                     39.4

Average Meter Temperature (C)=                       12
Average Delta H (mm H2O)=                          50.7
Average Delta P (mm H2O)=                          19.3
Average Stack Temperature (C)=                      447

Dry Molecular Weight=                             29.42
Wet Molecular Weight=                             24.92

Average Square Root of Delta P (mm H2O)=         4.3449
  Isokinetic=                                     107.6

Pitot Coefficient=                                 0.84
Sampling Time (Minutes)=                          120.0
Nozzle Diameter (mm)=                              8.05
Stack Axis #1 (Meters)=                           1.219
Stack Axis #2 (Meters)=                           1.219
Circular Stack
Stack Area (Square Meters)=                       1.167

Stack Velocity  (Actual, m/min)=                  1,506
Flow rate (Actual, Cubic m/min)=                  1,758
Flow rate (Standard, Wet, Cubic m/min)=             703
Flow rate (Standard, Dry, Cubic m/min)=             427

Particulate Loading - Front Half

Particulate Weight (g)=                         23.6502   Corr. to 7% O2 & 12% CO2
Particulate Loading, Dry Std. (mg/cu m)=         9845.5        8614.8   15545.6
Particulate Loading, Actual (mg/cu m)=           2387.8
Emission Rate (kg/hr)=                           251.63

No Back Half Analysis
```

F1

```
FILE NAME - 9102R1                                               PROG.=VER 06/27/89
RUN # - 1 - SDA MM5 METALS TRAIN                                 12-11-1989  23:51:36
LOCATION - Unit 4 SDA Inlet - TWI, Sauget, IL
DATE - 11/17/89
PROJECT # - 9102-57-20

 Point #      Delta P    Delta H   Stack T        Meter T
             (in. H2O) (in. H2O)    (F)     In(F)   Out(F)
  1           0.900       2.00      832       32       31
  2           0.740       1.70      805       45       38
  3           1.000       2.70      829       48       39
  4           1.100       2.70      829       50       40
  5           1.100       2.70      835       52       41
  6           0.930       2.70      841       53       41
  7           0.930       2.70      854       55       42
  8           0.740       1.60      850       43       42
  9           0.700       1.57      844       53       48
 10           0.670       1.57      842       56       49
 11           0.700       1.50      829       58       50
 12           0.550       1.60      825       60       51
 13           0.720       1.70      835       52       51
 14           0.560       2.20      830       59       53
 15           0.740       2.00      841       63       54
 16           0.900       2.50      835       64       55
 17           0.650       2.00      828       66       56
 18           0.920       2.50      839       67       57
 19           0.930       2.80      839       70       58
 20           0.770       2.30      846       71       59
 21           0.660       2.00      849       71       60
 22           0.480       1.50      842       70       60
 23           0.330       0.70      833       69       60
 24           0.240       0.40      836       66       60


Fraction                Final Wt. Tare Wt. Blank Wt. Net Wt.
                           (g)       (g)      (g)      (g)
DRY CATCH              36.9053   25.6422    0.0000   11.2631
FILTER                  5.5781    4.4899   -0.0002    1.0884

Fraction                Final Wt. Tare Wt.   Vol.    Net Wt.
                           (g)       (g)     (ml)      (g)
PROBE RINSE            79.7373   68.4336   640.0   11.2987
IMPINGERS               0.0000    0.0000     0.0    0.0000
Probe Rinse Blank (mg/ml)=  0.0340  High Acetone Blank - Limit .0079
Impinger Blank (mg/ml)=  0.0000

Multiple leak checks used.  Final readings for each segment are listed below

Lk Rate (cfm) Time (min)
    0.0030   35.0000
    0.0030   25.0000
    0.0060   60.0000
```

```
FILE NAME - 9102R2                                       PROG.=VER 06/27/89
RUN # - 2 - SDA MM5 METALS TRAIN                         12-11-1989  23:58:17
LOCATION - Unit 4 SDA Inlet - TWI, Sauget, IL
DATE - 11/18 AND 11/20 1989
PROJECT # - 9102-47-20

Initial Meter Volume (Cubic Feet)=           110.836
Final Meter Volume (Cubic Feet)=             183.559
Meter Factor=                                  0.990
Multiple leak checks, see end of printout               Leak Correction=  0.0000
Net Meter Volume (Cubic Feet)=                73.946
Gas Volume (Dry Standard Cubic Feet)=         73.846

Barometric Pressure (in Hg)=                   29.76
Static Pressure (Inches H2O)=                  -1.50

Percent Oxygen=                                  9.6
Percent Carbon Dioxide=                          8.8
Moisture Collected (ml)=                       831.9
Percent Water=                                  34.7

Average Meter Temperature (F)=                    89
Average Delta H (in H2O)=                       1.51
Average Delta P (in H2O)=                      0.682
Average Stack Temperature (F)=                   857

Dry Molecular Weight=                          29.79
Wet Molecular Weight=                          25.70

Average Square Root of Delta P (in H2O)=      0.8204
% Isokinetic=                                   93.1

Pitot Coefficient=                              0.84
Sampling Time (Minutes)=                       120.0
Nozzle Diameter (Inches)=                      0.317
Stack Axis #1 (Inches)=                         48.0
Stack Axis #2 (Inches)=                         48.0
Circular Stack
Stack Area (Square Feet)=                      12.57

Stack Velocity  (Actual, Feet/min)=            4,646
Flow Rate (Actual, Cubic ft/min)=             58,389
Flow rate (Standard, Wet, Cubic ft/min)=      23,195
Flow Rate (Standard, Dry, Cubic ft/min)=      15,154

Particulate Loading - Front Half

Particulate Weight (g)=                      23.4128    Corr. to 7% O2 & 12% CO2
Particulate Loading, Dry Std. (gr/scf)=       4.8825          5.9961     6.6580
Particulate Loading, Actual (gr/cu ft)=       1.2667
Emission Rate (lb/hr)=                        634.11

No Back Half Analysis
```

```
                          * * METRIC UNITS * *
FILE NAME - 9102R2                                       PROG.=VER 06/27/89
RUN # - 2 - SDA MM5 METALS TRAIN                         12-11-1989  23:58:19
LOCATION - Unit 4 SDA Inlet - TWI, Sauget, IL
DATE - 11/18 AND 11/20 1989
  PROJECT # - 9102-67-20

Initial Meter Volume (Cubic Meters)=                3.138
Final Meter Volume (Cubic Meters)=                  5.339
Meter Factor=                                       0.990
Multiple leak checks, see end of printout                   Leak Correction=  0.0000
Net Meter Volume (Cubic Meters)=                    2.179
Gas Volume (Dry Standard Cubic Meters)=             2.091

Barometric Pressure (mm Hg)=                          756
Static Pressure (mm H2O)=                             -38

Percent Oxygen=                                       9.6
Percent Carbon Dioxide=                               8.8
Moisture Collected (ml)=                            831.9
Percent Water=                                       34.7

Average Meter Temperature (C)=                         32
Average Delta H (mm H2O)=                            38.4
Average Delta P (mm H2O)=                            17.3
Average Stack Temperature (C)=                        458

Dry Molecular Weight=                               29.79
Wet Molecular Weight=                               25.70

Average Square Root of Delta P (mm H2O)=           4.1347
  Isokinetic=                                        93.1

Pitot Coefficient=                                   0.84
Sampling Time (Minutes)=                            120.0
Nozzle Diameter (mm)=                                8.05
Stack Axis #1 (Meters)=                             1.219
Stack Axis #2 (Meters)=                             1.219
Circular Stack
Stack Area (Square Meters)=                         1.167

Stack Velocity  (Actual, m/min)=                    1,416
Flow rate (Actual, Cubic m/min)=                    1,653
Flow rate (Standard, Wet, Cubic m/min)=               657
Flow rate (Standard, Dry, Cubic m/min)=               429

Particulate Loading - Front Half

Particulate Weight (g)=                           23.4128    Corr. to 7% O2 & 12% CO2
Particulate Loading, Dry Std. (mg/cu m)=          11196.8        13750.4   15268.3
Particulate Loading, Actual (mg/cu m)=             2904.9
Emission Rate (kg/hr)=                             287.88

No Back Half Analysis
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```
FILE NAME - 9102R2                                          PROG.=VER 06/27/89
RUN # - 2 - SDA MM5 METALS TRAIN                            12-11-1989  23:58:26
LOCATION - Unit 4 SDA Inlet - TWI, Sauget, IL
DATE - 11/18 AND 11/20 1989
PROJECT # - 9102-57-20

Point #       Delta P    Delta H    Stack T      Meter T
             (in. H2O) (in. H2O)     (F)      In(F)  Out(F)
 1             0.710       1.50       836        67      64
 2             0.630       1.30       828        79      68
 3             0.710       1.40       839        88      72
 4             0.800       1.66       842        92      76
 5             0.830       1.80       850        94      79
 6             0.830       1.80       850        93      81
 7             0.810       1.60       872        83      83
 8             0.750       1.50       872        86      84
 9             0.600       1.30       872        90      85
10             0.600       1.30       872        94      87
11             0.360       0.80       848        95      87
12             0.360       0.80       820        95      89
13             0.690       1.50       858        86      85
14             0.730       1.60       866        90      88
15             0.880       1.90       873        95      89
16             0.840       1.90       870        98      91
17             0.740       1.70       865       101      93
18             0.880       2.00       878       101      94
19             0.700       2.00       855        95      94
20             0.660       1.80       865        97      94
21             0.610       1.30       865        99      94
22             0.590       1.30       861        99      95
23             0.710       1.50       848        98      94
24             0.360       1.00       866        99      94


Fraction                Final Wt. Tare Wt. Blank Wt. Net Wt.
                           (g)       (g)       (g)       (g)
DRY CATCH               34.1378   25.7241    0.0000    8.4137
FILTER                  10.3641    8.9798   -0.0004    1.3847

Fraction                Final Wt. Tare Wt.   Vol.     Net Wt.
                           (g)       (g)     (ml)      (g)
PROBE RINSE             81.6865   68.0670   650.0   13.6144
IMPINGERS                0.0000    0.0000     0.0    0.0000
Probe Rinse Blank (mg/ml)=  0.0340  High Acetone Blank - Limit .0079
Impinger Blank (mg/ml)=  0.0000

Multiple leak checks used.  Final readings for each segment are listed below

Lk Rate (cfm) Time (min)
    0.0090    27.0000
    0.0100    33.0000
    0.0060    60.0000
```

```
FILE NAME - 910293
RUN # - 3 - SDA MM5 METALS TRAIN                              PROG.=VER 06/27/89
LOCATION - Unit 4 SDA Inlet - TWI, Sauget, IL                 12-11-1989  00:04:01
DATE - 11/21/89
PROJECT # - 9102-57-20

Initial Meter Volume (Cubic Feet)=                  194.376
Final Meter volume (Cubic Feet)=                    271.633
Meter Factor=                                         0.990
Multiple leak checks, see end of printout                      Leak Correction=  0.0000
Net Meter Volume (Cubic Feet)=                       76.484
Gas Volume (Dry Standard Cubic Feet)=                75.201

Barometric Pressure (in Hg)=                          29.67
Static Pressure (Inches H2O)=                         -1.50

Percent Oxygen=                                         9.4
Percent Carbon Dioxide=                                 9.0
Moisture Collected (ml)=                              907.8
Percent Water=                                         36.2

Average Meter Temperature (F)=                           74
Average Delta H (in H2O)=                              1.50
Average Delta P (in H2O)=                             0.627
Average Stack Temperature (F)=                          862

Dry Molecular Weight=                                 29.82
Wet Molecular Weight=                                 25.53

Average Square Root of Delta P (in H2O)=             0.7821
% Isokinetic=                                         101.9

Pitot Coefficient=                                     0.84
Sampling Time (Minutes)=                              120.0
Nozzle Diameter (Inches)=                             0.317
Stack Axis #1 (Inches)=                                48.0
Stack Axis #2 (Inches)=                                48.0
Circular Stack
Stack Area (Square Feet)=                             12.57

Stack Velocity  (Actual, Feet/min)=                   4,459
Flow Rate (Actual, Cubic ft/min)=                    56,028
Flow rate (Standard, Wet, Cubic ft/min)=             22,115
Flow Rate (Standard, Dry, Cubic ft/min)=             14,101

Particulate Loading - Front Half

Particulate Weight (g)=                             22.8113    Corr. to 7% O2 & 12% CO2
Particulate Loading, Dry Std. (gr/scf)=              4.6695         5.6357     6.2261
Particulate Loading, Actual (gr/cu ft)=              1.1748
Emission Rate (lb/hr)=                               564.30

No Back Half Analysis
```

```
                    * * METRIC UNITS * *
FILE NAME - 9102R3                                        PROG.=VER 06/27/89
RUN # - 3 - SDA MM5 METALS TRAIN                          12-11-1989  00:04:02
LOCATION - Unit 4 SDA Inlet - TWI, Sauget, IL
DATE - 11/21/89
  PROJECT # - 9102-37-20

Initial Meter Volume (Cubic Meters)=             5.504
Final Meter Volume (Cubic Meters)=               7.692
Meter Factor=                                    0.990
Multiple leak checks, see end of printout              Leak Correction=  0.0000
Net Meter Volume (Cubic Meters)=                 2.166
Gas Volume (Dry Standard Cubic Meters)=          2.130

Barometric Pressure (mm Hg)=                       754
Static Pressure (mm H2O)=                          -38

Percent Oxygen=                                    9.4
Percent Carbon Dioxide=                            9.0
Moisture Collected (ml)=                         907.8
Percent Water=                                    36.2

Average Meter Temperature (C)=                      23
Average Delta H (mm H2O)=                         32.2
Average Delta P (mm H2O)=                         15.9
Average Stack Temperature (C)=                     461

Dry Molecular Weight=                            29.82
Wet Molecular Weight=                            25.53

Average Square Root of Delta P (mm H2O)=        3.9417
  Isokinetic=                                    101.9

Pitot Coefficient=                                0.84
Sampling Time (Minutes)=                         120.0
Nozzle Diameter (mm)=                             8.05
Stack Axis #1 (Meters)=                          1.219
Stack Axis #2 (Meters)=                          1.219
Circular Stack
Stack Area (Square Meters)=                      1.167

Stack Velocity  (Actual, m/min)=                 1,359
Flow rate (Actual, Cubic m/min)=                 1,587
Flow rate (Standard, Wet, Cubic m/min)=            626
Flow rate (Standard, Dry, Cubic m/min)=            399

Particulate Loading - Front Half

Particulate Weight (g)=                        22.8113   Corr. to 7% O2 & 12% CO2
Particulate Loading, Dry Std. (mg/cu m)=       10708.3       12923.9   14277.8
Particulate Loading, Actual (mg/cu m)=          2694.0
Emission Rate (kg/hr)=                          256.19

No Back Half Analysis
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```
FILE NAME - 9102R3                                            PROG.=VER 06/27/89
RUN # - 3 - SDA MM5 METALS TRAIN                              12-11-1989  00:04:10
LOCATION - Unit 4 SDA Inlet - TWI, Saugat, IL
DATE - 11/21/89
PROJECT # - 9102-57-20

 oint #       Delta P    Delta H     Stack T       Meter T
            (in. H2O) (in. H2O)     (F)     In(F)   Out(F)
  1           0.570      1.20       870       58      57
  2           0.580      1.20       867       69      62
  3           0.550      1.40       870       74      64
  4           0.520      1.40       870       79      66
  5           0.620      1.50       863       81      68
  6           0.710      2.10       863       84      71
  7           0.670      1.80       875       69      68
  8           0.650      1.80       875       74      70
  9           0.480      1.10       847       79      71
  10          0.490      1.00       851       78      71
  11          0.290      0.50       840       77      71
  12          0.250      0.50       824       75      71
  13          0.660      1.50       866       65      66
  14          0.660      1.50       864       70      67
  15          0.700      1.60       878       77      69
  16          0.790      2.00       867       81      71
  17          0.700      1.90       884       82      72
  18          0.950      2.50       877       80      71
  19          0.880      2.40       865       86      73
  20          0.920      2.30       869       85      73
  21          0.800      2.00       862       87      74
  22          0.700      1.50       864       89      75
  23          0.360      0.80       833       91      77
   4          0.330      0.60       833       89      79


Fraction               Final Wt. Tare Wt. Blank Wt. Net Wt.
                          (g)       (g)       (g)      (g)
DRY CATCH              37.2637   25.7427    0.0000   11.5210
FILTER                  5.4626    4.5108   -0.0002    0.9520

Fraction               Final Wt. Tare Wt.   Vol.     Net Wt.
                          (g)       (g)     (ml)       (g)
PROBE RINSE            77.6671   67.3244   560.0   10.3383
IMPINGERS               0.0000    0.0000     0.0    0.0000
Probe Rinse Blank (mg/ml)=  0.0340  High Acetone Blank - Limit .0079
Impinger Blank (mg/ml)=  0.0000

Multiple leak checks used.  Final readings for each segment are listed below

Lk Rate (cfm) Time (min)
    0.0030    60.0000
    0.0020    60.0000
```

```
FILE NAME - twi06m1                                             PROG.=VER 06/09/89
RUN # - 1 - MULTIPLE METALS TRAIN                               12-13-1989  11:08:51
LOCATION - Unit 4 Stack - TWI, Sauget. IL
DATE - 11/17/89
PROJECT # - 9304L-06-32

Initial Meter Volume (Cubic Feet)=                   315.764
Final Meter Volume (Cubic Feet)=                     369.510
Meter Factor=                                          1.040
Multiple leak checks, see end of printout                      Leak Correction=  0.0000
Net Meter Volume (Cubic Feet)=                        55.896
Gas Volume (Dry Standard Cubic Feet)=                 53.538

Barometric Pressure (in Hg)=                           29.56
Static Pressure (Inches H20)=                          -0.30

Percent Oxygen=                                         11.2
Percent Carbon Dioxide=                                  7.6
Moisture Collected (ml)=                               715.2
Percent Water=                                          38.6

Average Meter Temperature (F)=                            85
Average Delta H (in H20)=                               0.65
Average Delta P (in H20)=                              0.672
Average Stack Temperature (F)=                           347

Dry Molecular Weight=                                  29.66
Wet Molecular Weight=                                  25.16

Average Square Root of Delta P (in H20)=              0.8102
% Isokinetic=                                           98.4

Pitot Coefficient=                                      0.83
Sampling Time (Minutes)=                               120.0
Nozzle Diameter (Inches)=                              0.241
Stack Axis #1 (Inches)=                                 48.0
Stack Axis #2 (Inches)=                                 48.0
Circular Stack
Stack Area (Square Feet)=                              12.57

Stack Velocity  (Actual, Feet/min)=                    3,612
Flow Rate (Actual, Cubic ft/min)=                     45,385
Flow rate (Standard, Wet, Cubic ft/min)=              29,309
Flow Rate (Standard, Dry, Cubic ft/min)=              17,990

Particulate Loading - Front Half

Particulate Weight (g)=                               0.0226    Corr. to 7% 02 & 12% CC
Particulate Loading, Dry Std. (gr/scf)=               0.0065        0.0093     0.0103
Particulate Loading, Actual (gr/cu ft)=               0.0026
Emission Rate (lb/hr)=                                  1.00

No Back Half Analysis
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```
                        * * METRIC UNITS * *
FILE NAME - tw106m1                                    PROG.=VER 06/09/89
RUN # - 1 - MULTIPLE METALS TRAIN                      12-13-1989  11:08:54
LOCATION - Unit 4 Stack - TWI, Sauget, IL
DATE - 11/17/89
PROJECT # - 9304L-06-32

Initial Meter Volume (Cubic Meters)=               8.941
Final Meter Volume (Cubic Meters)=                10.463
Meter Factor=                                      1.040
Multiple leak checks. see end of printout            Leak Correction=  0.0000
Net Meter Volume (Cubic Meters)=                   1.583
Gas Volume (Dry Standard Cubic Meters)=            1.516

Barometric Pressure (mm Hg)=                         751
Static Pressure (mm H2O)=                             -8

Percent Oxygen=                                     11.2
Percent Carbon Dioxide=                              7.6
Moisture Collected (ml)=                           715.2
Percent Water=                                      38.6

Average Meter Temperature (C)=                        30
Average Delta H (mm H2O)=                           16.6
Average Delta P (mm H2O)=                           17.1
Average Stack Temperature (C)=                       175

Dry Molecular Weight=                              29.66
Wet Molecular Weight=                              25.16

Average Square Root of Delta P (mm H2O)=          4.0831
% Isokinetic=                                       98.4

Pitot Coefficient=                                  0.83
Sampling Time (Minutes)=                           120.0
Nozzle Diameter (mm)=                               6.12
Stack Axis #1 (Meters)=                            1.219
Stack Axis #2 (Meters)=                            1.219
Circular Stack
Stack Area (Square Meters)=                        1.167

Stack Velocity  (Actual, m/min)=                   1,101
Flow rate (Actual, Cubic m/min)=                   1,285
Flow rate (Standard, Wet, Cubic m/min)=              830
Flow rate (Standard, Dry, Cubic m/min)=              509

Particulate Loading - Front Half

Particulate Weight (g)=                           0.0226   Corr. to 7% O2 & 12% CO
Particulate Loading, Dry Std. (mg/cu m)=            14.9         21.3        23.5
Particulate Loading, Actual (mg/cu m)=               5.9
Emission Rate (kg/hr)=                              0.46

No Back Half Analysis
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```
FILE NAME - twi06m1                                          PROG.=VER 06/09/89
RUN # - 1 - MULTIPLE METALS TRAIN                            12-13-1989  11:08:56
LOCATION - Unit 4 Stack - TWI, Sauget, IL
DATE - 11/17/89
PROJECT # - 9304L-06-32

Point #      Delta P    Delta H    Stack T      Meter T
            (in. H2O)  (in. H2O)    (F)     In(F)   Out(F)
  1           0.320      0.33       354      74      74
  2           0.450      0.46       354      75      75
  3           0.550      0.55       367      79      74
  4           0.500      0.48       360      82      75
  5           0.880      0.76       361      85      77
  6           0.790      0.74       355      88      78
  7           0.930      0.84       371      90      81
  8           0.960      0.88       351      93      81
  9           0.930      0.96       350      96      83
  10          0.860      0.92       350      97      84
  11          0.640      0.67       346      97      85
  12          0.650      0.69       343      98      87
  13          0.450      0.48       341      88      87
  14          0.440      0.45       334      87      87
  15          0.440      0.43       340      90      87
  16          0.460      0.43       342      90      86
  17          0.450      0.44       345      90      86
  18          0.880      0.89       343      86      85
  19          0.970      0.94       341      86      85
  20          0.890      0.84       341      87      83
  21          0.700      0.66       337      90      84
  22          0.760      0.72       336      90      84
  23          0.620      0.57       334      89      84
  24          0.610      0.58       336      90      85


Fraction                  Final Wt. Tare Wt. Blank Wt. Net Wt.
                            (g)       (g)       (g)      (g)
DRY CATCH                 0.0000    0.0000    0.0000    0.0000
FILTER                    4.5260    4.5163   -0.0002    0.0099

Fraction                  Final Wt. Tare Wt.   Vol.     Net Wt.
                            (g)       (g)      (ml)      (g)
PROBE RINSE             67.1327   67.1190    125.0    0.0127
IMPINGERS                0.0000    0.0000      0.0    0.0000
Probe Rinse Blank (mg/ml)=  0.0340  High Acetone Blank - Limit .0079
Impinger Blank (mg/ml)=  0.0000

Multiple leak checks used.  Final readings for each segment are listed below

Lk Rate (cfm) Time (min)
    0.0050   60.0000
    0.0020   60.0000
```

```
FILE NAME - TWI06M2                                              PROG.=VER 06/27/89
RUN # - 2 - MULTIPLE METALS TRAIN                                12-09-1989  20:05:06
LOCATION - Unit 4 Stack - TWI, Sauget, IL
DATE - 11/18 AND 11/20 1989
PROJECT # - 9304L-06-32

Initial Meter Volume (Cubic Feet)=                       370.200
Final Meter Volume (Cubic Feet)=                         428.385
Meter Factor=                                              1.040
Multiple leak checks, see end of printout                          Leak Correction=  0.0000
Net Meter Volume (Cubic Feet)=                            58.432
Gas Volume (Dry Standard Cubic Feet)=                     56.680

Barometric Pressure (in Hg)=                               29.62
Static Pressure (Inches H2O)=                              -0.30

Percent Oxygen=                                             10.6
Percent Carbon Dioxide=                                      7.2
Moisture Collected (ml)=                                   743.2
Percent Water=                                              38.2

Average Meter Temperature (F)=                                80
Average Delta H (in H2O)=                                   0.74
Average Delta P (in H2O)=                                  0.738
Average Stack Temperature (F)=                               359

Dry Molecular Weight=                                      29.58
Wet Molecular Weight=                                      25.16

Average Square Root of Delta P (in H2O)=                  0.8545
% Isokinetic=                                               98.7

Pitot Coefficient=                                          0.83
Sampling Time (Minutes)=                                   120.0
Nozzle Diameter (Inches)=                                  0.241
Stack Axis #1 (Inches)=                                     48.0
Stack Axis #2 (Inches)=                                     48.0
Circular Stack
Stack Area (Square Feet)=                                  12.57

Stack Velocity  (Actual, Feet/min)=                        3,834
Flow Rate (Actual, Cubic ft/min)=                         48,178
Flow rate (Standard, Wet, Cubic ft/min)=                  30,718
Flow Rate (Standard, Dry, Cubic ft/min)=                  18,990

Particulate Loading - Front Half

Particulate Weight (g)=                                   0.0510    Corr. to 7% O2 & 12% CO2
Particulate Loading, Dry Std. (gr/scf)=                   0.0139        0.0187       0.0231
Particulate Loading, Actual (gr/cu ft)=                   0.0055
Emission Rate (lb/hr)=                                      2.26

No Back Half Analysis
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                            * * METRIC UNITS * *
FILE NAME - TWI06MC                                       PROG.=VER 06/27/89
RUN # - 2 - MULTIPLE METALS TRAIN                         12-09-1989  20:05:07
LOCATION - Unit 4 Stack - TWI, Sauget, IL
DATE - 11/18 AND 11/20 1989
PROJECT # - 9304L-06-02

Initial Meter Volume (Cubic Meters)=               10.483
Final Meter Volume (Cubic Meters)=                 12.074
Meter Factor=                                       1.040
Multiple leak checks, see end of printout                   Leak Correction=  0.0000
Net Meter Volume (Cubic Meters)=                    1.655
Gas Volume (Dry Standard Cubic Meters)=             1.605

Barometric Pressure (mm Hg)=                          752
Static Pressure (mm H2O)=                              -8

Percent Oxygen=                                      10.6
Percent Carbon Dioxide=                               7.2
Moisture Collected (ml)=                            743.2
Percent Water=                                       38.2

Average Meter Temperature (C)=                         26
Average Delta H (mm H2O)=                            18.9
Average Delta P (mm H2O)=                            18.7
Average Stack Temperature (C)=                        182

Dry Molecular Weight=                               29.58
Wet Molecular Weight=                               25.16

Average Square Root of Delta P (mm H2O)=           4.3066
% Isokinetic=                                        98.7

Pitot Coefficient=                                   0.83
Sampling Time (Minutes)=                            120.0
Nozzle Diameter (mm)=                                6.12
Stack Axis #1 (Meters)=                             1.219
Stack Axis #2 (Meters)=                             1.219
Circular Stack
Stack Area (Square Meters)=                         1.167

Stack Velocity  (Actual, m/min)=                    1,169
Flow rate (Actual, Cubic m/min)=                    1,364
Flow rate (Standard, Wet, Cubic m/min)=               870
Flow rate (Standard, Dry, Cubic m/min)=               538

Particulate Loading - Front Half

Particulate Weight (g)=                            0.0510     Corr. to 7% O2 & 12% CO2
Particulate Loading, Dry Std. (mg/cu m)=             31.8          42.8         53.0
Particulate Loading, Actual (mg/cu m)=               12.5
Emission Rate (kg/hr)=                               1.02

No Back Half Analysis
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```
FILE NAME - TWI06M2                                      PROG.=VER 06/27/89
RUN # - 2 - MULTIPLE METALS TRAIN                        12-09-1989  20:05:15
LOCATION - Unit 4 Stack - TWI, Sauget, IL
DATE - 11/18 AND 11/20 1989
PROJECT # - 9304L-06-32

Point #       Delta P   Delta H    Stack T       Meter T
             (in. H2O) (in. H2O)    (F)      In(F)   Out(F)
   1           0.560      0.56      360        76       75
   2           0.550      0.55      354        77       75
   3           0.620      0.62      355        80       75
   4           0.660      0.67      354        83       76
   5           0.750      0.75      354        86       77
   6           0.810      0.81      369        82       77
   7           0.830      0.81      376        74       74
   8           0.800      0.79      371        76       75
   9           0.880      0.87      370        79       75
  10           0.830      0.83      364        78       77
  11           0.740      0.74      360        77       76
  12           0.710      0.72      358        79       77
  13           0.380      0.38      346        77       76
  14           0.420      0.43      347        77       77
  15           0.860      0.86      360        79       77
  16           0.900      0.91      362        82       78
  17           0.920      0.93      360        84       78
  18           0.850      0.85      358        86       77
  19           0.830      0.84      358        88       79
  20           0.820      0.84      356        89       81
  21           0.790      0.81      356        89       81
  22           0.800      0.81      360        88       82
  23           0.700      0.72      356        88       82
  24           0.700      0.72      357        89       83


Fraction                 Final Wt. Tare Wt. Blank Wt. Net Wt.
                            (g)       (g)       (g)       (g)
DRY CATCH                 0.0000    0.0000    0.0000    0.0000
FILTER                    4.5322    4.5035   -0.0002    0.0289

Fraction                 Final Wt. Tare Wt.   Vol.     Net Wt.
                            (g)       (g)     (ml)       (g)
PROBE RINSE              69.4846   69.4618    88.0     0.0221
IMPINGERS                 0.0000    0.0000     0.0     0.0000
Probe Rinse Blank (mg/ml)=  0.0340  High Acetone Blank - Limit .0079
Impinger Blank (mg/ml)=  0.0000

Multiple leak checks used.  Final readings for each segment are listed below

Lk Rate (cfm) Time (min)
    0.0050    30.0000
    0.0010    30.0000
    0.0010    60.0000
```

```
FILE NAME - TWI03M3                                   PROG.=VER 06/27/89
RUN # - 3 - MULTIPLE METALS TRAIN                     12-09-1989  20:32:14
LOCATION - Unit 1 Stack - TWI, Sauget, IL
DATE - 11/21/89
PROJECT # - 9304L-06-32

Initial Meter Volume (Cubic Feet)=          431.901
Final Meter Volume (Cubic Feet)=            491.009
Meter Factor=                                 1.040
Multiple leak checks, see end of printout             Leak Correction=  0.0000
Net Meter Volume (Cubic Feet)=               61.472
Gas Volume (Dry Standard Cubic Feet)=        59.278

Barometric Pressure (in Hg)=                  29.73
Static Pressure (Inches H20)=                 -0.30

Percent Oxygen=                                11.4
Percent Carbon Dioxide=                         7.2
Moisture Collected (ml)=                      792.2
Percent Water=                                 38.6

Average Meter Temperature (F)=                   85
Average Delta H (in H20)=                      0.81
Average Delta P (in H20)=                     0.770
Average Stack Temperature (F)=                  356

Dry Molecular Weight=                         29.61
Wet Molecular Weight=                         25.12

Average Square Root of Delta P (in H20)=     0.8757
% Isokinetic=                                 101.0

Pitot Coefficient=                             0.83
Sampling Time (Minutes)=                      120.0
Nozzle Diameter (Inches)=                     0.241
Stack Axis #1 (Inches)=                        48.0
Stack Axis #2 (Inches)=                        48.0
Circular Stack
Stack Area (Square Feet)=                     12.57

Stack Velocity  (Actual, Feet/min)=           3,916
Flow Rate (Actual, Cubic ft/min)=            49,207
Flow rate (Standard, Wet, Cubic ft/min)=     31,630
Flow Rate (Standard, Dry, Cubic ft/min)=     19,412

Particulate Loading - Front Half

Particulate Weight (g)=                      0.0412    Corr. to 7% O2 & 12% CO2
Particulate Loading, Dry Std. (gr/scf)=      0.0107        0.0156      0.0179
Particulate Loading, Actual (gr/cu ft)=      0.0042
Emission Rate (lb/hr)=                         1.78

No Back Half Analysis
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                         * * METRIC UNITS * *
FILE NAME - TWI06M3
RUN # - 3 - MULTIPLE METALS TRAIN                        PROG.=VER 06/27/89
LOCATION - Unit 4 Stack - TWI, Sauget, IL                12-09-1989  20:32:16
DATE - 11/21/89
PROJECT # - 9304L-06-32

Initial Meter Volume (Cubic Meters)=              12.230
Final Meter Volume (Cubic Meters)=                13.903
Meter Factor=                                      1.040
Multiple leak checks, see end of printout                 Leak Correction=  0.0000
Net Meter Volume (Cubic Meters)=                   1.741
Gas Volume (Dry Standard Cubic Meters)=            1.679

Barometric Pressure (mm Hg)=                         755
Static Pressure (mm H2O)=                             -8

Percent Oxygen=                                     11.4
Percent Carbon Dioxide=                              7.2
Moisture Collected (ml)=                           792.2
Percent Water=                                      38.6

Average Meter Temperature (C)=                        29
Average Delta H (mm H2O)=                           20.5
Average Delta P (mm H2O)=                           19.6
Average Stack Temperature (C)=                       180

Dry Molecular Weight=                              29.61
Wet Molecular Weight=                              25.12

Average Square Root of Delta P (mm H2O)=          4.4136
% Isokinetic=                                      101.0

Pitot Coefficient=                                  0.83
Sampling Time (Minutes)=                           120.0
Nozzle Diameter (mm)=                               6.12
Stack Axis #1 (Meters)=                            1.219
Stack Axis #2 (Meters)=                            1.219
Circular Stack
Stack Area (Square Meters)=                        1.167

Stack Velocity  (Actual, m/min)=                   1,194
Flow rate (Actual, Cubic m/min)=                   1,393
Flow rate (Standard, Wet, Cubic m/min)=              896
Flow rate (Standard, Dry, Cubic m/min)=              550

Particulate Loading - Front Half

Particulate Weight (g)=                           0.0412   Corr. to 7% O2 & 12% CO2
Particulate Loading, Dry Std. (mg/cu m)=            24.6        35.8        41.0
Particulate Loading, Actual (mg/cu m)=               9.7
Emission Rate (kg/hr)=                              0.81

No Back Half Analysis
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FILE NAME - TWI06M3                                        PROG.=VER 06/27/89
RUN # - 3 - MULTIPLE METALS TRAIN                          12-09-1989  20:32:23
LOCATION - Unit 4 Stack - TWI. Sauget, IL
DATE - 11/21/89
PROJECT # - 9304L-06-30

Point #      Delta P    Delta H     Stack T       Meter T
            (in. H2O) (in. H2O)      (F)     In(F)   Out(F)
  1           0.860       0.88       359       74       72
  2           0.600       0.62       355       76       74
  3           0.750       0.78       357       81       75
  4           0.730       0.76       358       84       76
  5           0.740       0.77       360       85       77
  6           0.850       0.87       360       86       79
  7           0.920       0.96       358       87       79
  8           0.870       0.90       358       90       80
  9           0.810       0.85       358       89       81
 10           0.800       0.84       356       91       82
 11           0.730       0.77       355       92       84
 12           0.690       0.73       355       93       84
 13           0.590       0.62       352       83       83
 14           0.580       0.61       350       82       82
 15           0.800       0.85       353       86       84
 16           0.840       0.89       353       88       83
 17           0.810       0.86       352       91       84
 18           0.820       0.87       356       92       85
 19           0.860       0.91       356       92       85
 20           0.900       0.95       357       94       85
 21           0.810       0.86       356       95       86
 22           0.790       0.84       354       96       87
              0.670       0.71       355       95       87
 24           0.660       0.67       351       94       87


Fraction               Final Wt.  Tare Wt.  Blank Wt.  Net Wt.
                          (g)       (g)        (g)       (g)
DRY CATCH               0.0000    0.0000     0.0000    0.0000
FILTER                  4.5168    4.5074    -0.0002    0.0096

Fraction               Final Wt.  Tare Wt.    Vol.     Net Wt.
                          (g)       (g)       (ml)       (g)
PROBE RINSE            66.5770   66.5443     135.0     0.0316
IMPINGERS               0.0000    0.0000       0.0     0.0000
Probe Rinse Blank (mg/ml)=  0.0340  High Acetone Blank - Limit .0079
Impinger Blank (mg/ml)=  0.0000

Multiple leak checks used.  Final readings for each segment are listed below

Lk Rate (cfm) Time (min)
    0.0010   60.0000
    0.0010   60.0000
```

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FILE NAME - 2twi06p1                                          PROG.=VER 06/27/89
RUN # - 1 - PARTICULATE/HCL TRAIN                             12-22-1989  19:39:24
LOCATION - Unit 4 Stack - TWI, Sauget, IL
DATE - 11/17/89
PROJECT # - 9304L-06-32

Initial Meter Volume (Cubic Feet)=                  472.800
Final Meter Volume (Cubic Feet)=                    524.020
Meter Factor=                                         1.079
Multiple leak checks, see end of printout                    Leak Correction=  0.0000
Net Meter Volume (Cubic Feet)=                       55.266
Gas Volume (Dry Standard Cubic Feet)=                51.292

Barometric Pressure (in Hg)=                          29.56
Static Pressure (Inches H2O)=                         -0.30

Percent Oxygen=                                        11.2
Percent Carbon Dioxide=                                 7.6
Moisture Collected (ml)=                              699.6
Percent Water=                                         39.1

Average Meter Temperature (F)=                          103
Average Delta H (in H2O)=                              0.62
Average Delta P (in H2O)=                             0.796
Average Stack Temperature (F)=                          349

Dry Molecular Weight=                                 29.66
Wet Molecular Weight=                                 25.10

Average Square Root of Delta P (in H2O)=             0.8897
% Isokinetic=                                         110.5

Pitot Coefficient=                                     0.81
Sampling Time (Minutes)=                              120.0
Nozzle Diameter (Inches)=                             0.217
Stack Axis #1 (Inches)=                                48.0
Stack Axis #2 (Inches)=                                48.0
Circular Stack
Stack Area (Square Feet)=                             12.57

Stack Velocity  (Actual, Feet/min)=                   3,843
Flow Rate (Actual, Cubic ft/min)=                    48,288
Flow rate (Standard, Wet, Cubic ft/min)=             31,098
Flow Rate (Standard, Dry, Cubic ft/min)=             18,934

Particulate Loading - Front Half

Particulate Weight (g)=                              0.0203     Corr. to 7% O2 & 12% CO2
Particulate Loading, Dry Std. (gr/scf)=              0.0061          0.0087     0.0096
Particulate Loading, Actual (gr/cu ft)=              0.0024
Emission Rate (lb/hr)=                                 0.99

No Back Half Analysis
```

```
                         * * METRIC UNITS * *
FILE NAME - 2twi06p1                                        PROG.=VER 06/27/89
RUN # - 1 - PARTICULATE/HCL TRAIN                           12-22-1989  19:39:52
LOCATION - Unit 4 Stack - TWI, Sauget, IL
DATE - 11/17/89
PROJECT # - 9304L-06-32

Initial Meter Volume (Cubic Meters)=               13.388
Final Meter Volume (Cubic Meters)=                 14.838
Meter Factor=                                       1.079
Multiple leak checks, see end of printout                   Leak Correction=  0.0000
Net Meter Volume (Cubic Meters)=                    1.565
Gas Volume (Dry Standard Cubic Meters)=             1.452

Barometric Pressure (mm Hg)=                          751
Static Pressure (mm H2O)=                              -8

Percent Oxygen=                                      11.2
Percent Carbon Dioxide=                               7.6
Moisture Collected (ml)=                            699.6
Percent Water=                                       39.1

Average Meter Temperature (C)=                         39
Average Delta H (mm H2O)=                            15.7
Average Delta P (mm H2O)=                            20.2
Average Stack Temperature (C)=                        176

Dry Molecular Weight=                               29.66
Wet Molecular Weight=                               25.10

Average Square Root of Delta P (mm H2O)=           4.4839
  %Isokinetic=                                      110.5

Pitot Coefficient=                                   0.81
Sampling Time (Minutes)=                            120.0
Nozzle Diameter (mm)=                                5.51
Stack Axis #1 (Meters)=                             1.219
Stack Axis #2 (Meters)=                             1.219
Circular Stack
Stack Area (Square Meters)=                         1.167

Stack Velocity  (Actual, m/min)=                    1,171
Flow rate (Actual, Cubic m/min)=                    1,367
Flow rate (Standard, Wet, Cubic m/min)=               881
Flow rate (Standard, Dry, Cubic m/min)=               536

Particulate Loading - Front Half

Particulate Weight (g)=                            0.0203    Corr. to 7% O2 & 12% CO2
Particulate Loading, Dry Std. (mg/cu m)=             14.0         20.0       22.1
Particulate Loading, Actual (mg/cu m)=                5.5
Emission Rate (kg/hr)=                               0.45

No Back Half Analysis
```

```
FILE NAME - 2twi06p1                                          PROG.=VER 06/27/89
RUN # - 1 - PARTICULATE/HCL TRAIN                             12-22-1989  19:40:19
LOCATION - Unit 4 Stack - TWI, Sauget, IL
DATE - 11/17/89
PROJECT # - 9304L-06-32

 Pnt #        Delta P    Delta H     Stack T        Meter T
            (in. H20)  (in. H20)      (F)      In(F)   Out(F)
  1           0.660      0.50         358        90       91
  2           0.630      0.45         357        92       87
  3           0.620      0.44         356        95       88
  4           0.820      0.60         358        98       90
  5           0.920      0.65         365       102       92
  6           0.900      0.67         359       106       94
  7           0.840      0.63         356       108       96
  8           0.960      0.80         354       111       99
  9           0.910      0.75         356       113      102
 10           0.840      0.70         350       116      103
 11           0.670      0.55         350       117      105
 12           0.600      0.25         344       118      107
 13           0.830      0.65         344       109      106
 14           0.740      0.63         343       109      105
 15           0.850      0.74         342       112      105
 16           0.850      0.76         342       114      106
 17           0.860      0.75         345       112      105
 18           0.940      0.75         348       109      102
 19           0.850      0.64         347       108      101
 20           0.900      0.66         347       106      101
 21           0.810      0.63         343       103       99
 22           0.850      0.65         342       102       98
 23           0.620      0.45         343       102       97
 24           0.630      0.52         336       102       97


Fraction               Final Wt.  Tare Wt.  Blank Wt.  Net Wt.
                          (g)        (g)       (g)        (g)
DRY CATCH              0.0000     0.0000     0.0000     0.0000
FILTER                 4.4799     4.4747    -0.0002     0.0054

Fraction               Final Wt.  Tare Wt.     Vol.     Net Wt.
                          (g)        (g)       (ml)       (g)
PROBE RINSE           67.4614    67.4454     135.0     0.0149
IMPINGERS              0.0000     0.0000       0.0     0.0000
Probe Rinse Blank (mg/ml)=  0.0340  High Acetone Blank - Limit .0079
Impinger Blank (mg/ml)=  0.0000

Multiple leak checks used.  Final readings for each segment are listed below

Lk Rate (cfm) Time (min)
     0.0020    60.0000
     0.0000    60.0000
```

```
FILE NAME - 2twi06p2                                              PROG.=VER 06/27/89
RUN # - 2 - PARTICULATE/HCL TRAIN                                 12-22-1989  20:19:29
LOCATION - Unit 4 Stack - TWI, Sauget, IL
DATE - 11/20/89
PROJECT # - 9304L-06-32

   tial Meter Volume (Cubic Feet)=                    538.800
Final Meter Volume (Cubic Feet)=                      588.650
Meter Factor=                                           1.079
Multiple leak checks, see end of printout                        Leak Correction=  0.0000
Net Meter Volume (Cubic Feet)=                         53.788
Gas Volume (Dry Standard Cubic Feet)=                  50.831

Barometric Pressure (in Hg)=                            29.50
Static Pressure (Inches H2O)=                           -0.30

Percent Oxygen=                                          10.6
Percent Carbon Dioxide=                                   7.2
Moisture Collected (ml)=                                674.4
Percent Water=                                           38.5

Average Meter Temperature (F)=                             91
Average Delta H (in H2O)=                                0.60
Average Delta P (in H2O)=                               0.823
Average Stack Temperature (F)=                            362

Dry Molecular Weight=                                   29.58
Wet Molecular Weight=                                   25.12

Average Square Root of Delta P (in H2O)=               0.9054
% Isokinetic=                                           104.8

   cot Coefficient=                                      0.83
Sampling Time (Minutes)=                                120.0
Nozzle Diameter (Inches)=                               0.217
Stack Axis #1 (Inches)=                                  48.0
Stack Axis #2 (Inches)=                                  48.0
Circular Stack
Stack Area (Square Feet)=                               12.57

Stack Velocity  (Actual, Feet/min)=                     4,041
Flow Rate (Actual, Cubic ft/min)=                      50,783
Flow rate (Standard, Wet, Cubic ft/min)=               32,130
Flow Rate (Standard, Dry, Cubic ft/min)=               19,774

Particulate Loading - Front Half

Particulate Weight (g)=                                0.0249    Corr. to 7% O2 & 12% CO2
Particulate Loading, Dry Std. (gr/scf)=                0.0076         0.0102      0.0126
Particulate Loading, Actual (gr/cu ft)=                0.0029
Emission Rate (lb/hr)=                                   1.28

No Back Half Analysis
```

```
                         * * METRIC UNITS * *
FILE NAME - 2twi06p2
RUN # - 2 - PARTICULATE/HCL TRAIN                              PROG.=VER 06/27/89
LOCATION - Unit 4 Stack - TWI, Sauget, IL                      12-22-1989  20:19:57
DATE - 11/20/89
PROJECT # - 9304L-06-32

Initial Meter Volume (Cubic Meters)=                    15.257
Final Meter Volume (Cubic Meters)=                      16.668
Meter Factor=                                            1.079
Multiple leak checks, see end of printout
Net Meter Volume (Cubic Meters)=                         1.523   Leak Correction=  0.0000
Gas Volume (Dry Standard Cubic Meters)=                  1.439

Barometric Pressure (mm Hg)=                               749
Static Pressure (mm H2O)=                                   -8

Percent Oxygen=                                           10.6
Percent Carbon Dioxide=                                    7.2
Moisture Collected (ml)=                                 674.4
Percent Water=                                            38.5

Average Meter Temperature (C)=                              33
Average Delta H (mm H2O)=                                 15.3
Average Delta P (mm H2O)=                                 20.9
Average Stack Temperature (C)=                             183

Dry Molecular Weight=                                    29.58
Wet Molecular Weight=                                    25.12

Average Square Root of Delta P (mm H2O)=                4.5628
% Isokinetic=                                            104.8

Pitot Coefficient=                                        0.83
Sampling Time (Minutes)=                                 120.0
Nozzle Diameter (mm)=                                     5.51
Stack Axis #1 (Meters)=                                  1.219
Stack Axis #2 (Meters)=                                  1.219
Circular Stack
Stack Area (Square Meters)=                              1.167

Stack Velocity  (Actual, m/min)=                         1,232
Flow rate (Actual, Cubic m/min)=                         1,438
Flow rate (Standard, Wet, Cubic m/min)=                    910
Flow rate (Standard, Dry, Cubic m/min)=                    560

Particulate Loading - Front Half

Particulate Weight (g)=                                 0.0249   Corr. to 7% O2 & 12% CO2
Particulate Loading, Dry Std. (mg/cu m)=                  17.3        23.3        28.9
Particulate Loading, Actual (mg/cu m)=                     6.7
Emission Rate (kg/hr)=                                    0.58

No Back Half Analysis
```

```
FILE NAME - 2twi06p2                                        PROG.=VER 06/27/89
RUN # - 2 - PARTICULATE/HCL TRAIN                           12-22-1989  20:20:23
LOCATION - Unit 4 Stack - TWI, Sauget, IL
DATE - 11/20/89
PROJECT # - 9304L-06-32

 int #      Delta P    Delta H     Stack T      Meter T
           (in. H2O)  (in. H2O)     (F)     In(F)   Out(F)
 1          0.750       0.55        376       92      95
 2          0.830       0.65        377       93      89
 3          0.830       0.70        376       97      90
 4          0.870       0.65        372      101      94
 5          0.950       0.65        371      104      95
 6          0.960       0.70        362      102      96
 7          0.900       0.75        362       91      90
 8          0.900       0.65        362       89      88
 9          0.790       0.55        362       91      86
 10         0.790       0.55        360       91      87
 11         0.690       0.50        360       91      87
 12         0.640       0.45        358       90      86
 13         0.780       0.56        358       85      86
 14         0.860       0.61        357       85      86
 15         0.880       0.67        359       89      88
 16         0.940       0.70        360       94      89
 17         0.950       0.71        359       96      89
 18         0.890       0.65        357       96      89
 19         0.850       0.63        358       96      89
 20         0.920       0.65        356       96      89
 21         0.770       0.53        358       95      90
 22         0.840       0.60        359       94      89
 23         0.600       0.43        359       94      89
 24         0.580       0.40        355       94      89


Fraction               Final Wt.  Tare Wt.  Blank Wt.  Net Wt.
                         (g)        (g)        (g)       (g)
DRY CATCH              0.0000     0.0000     0.0000    0.0000
FILTER                 4.5403     4.5279    -0.0002    0.0126

Fraction               Final Wt.  Tare Wt.    Vol.     Net Wt.
                         (g)        (g)       (ml)       (g)
PROBE RINSE           69.0212    69.0078    135.0     0.0123
IMPINGERS              0.0000     0.0000      0.0     0.0000
Probe Rinse Blank (mg/ml)=  0.0340  High Acetone Blank - Limit .0079
Impinger Blank (mg/ml)=  0.0000

Multiple leak checks used.  Final readings for each segment are listed below

Lk Rate (cfm) Time (min)
    0.0050   60.0000
    0.0000   60.0000
```

```
FILE NAME - 2twi06p3
RUN # - 3 - PARTICULATE/HCL TRAIN                           PROG.=VER 06/27/89
LOCATION - Unit 4 Stack - TWI, Sauget, IL                   12-22-1989  20:23:29
DATE - 11/21/89
PROJECT # - 9304L-06-32

Initial Meter Volume (Cubic Feet)=                   589.600
Final Meter Volume (Cubic Feet)=                     638.250
Meter Factor=                                          1.079
Multiple leak checks, see end of printout                       Leak Correction=  0.0000
Net Meter Volume (Cubic Feet)=                        52.493
Gas Volume (Dry Standard Cubic Feet)=                 49.304

Barometric Pressure (in Hg)=                           29.73
Static Pressure (Inches H2O)=                          -0.30

Percent Oxygen=                                         11.4
Percent Carbon Dioxide=                                  7.2
Moisture Collected (ml)=                               661.2
Percent Water=                                          38.7

Average Meter Temperature (F)=                            99
Average Delta H (in H2O)=                               0.57
Average Delta P (in H2O)=                              0.754
Average Stack Temperature (F)=                           358

Dry Molecular Weight=                                  29.61
Wet Molecular Weight=                                  25.11

Average Square Root of Delta P (in H2O)=              0.8668
% Isokinetic=                                          106.0

Pitot Coefficient=                                      0.83
Sampling Time (Minutes)=                               120.0
Nozzle Diameter (Inches)=                              0.217
Stack Axis #1 (Inches)=                                 48.0
Stack Axis #2 (Inches)=                                 48.0
Circular Stack
Stack Area (Square Feet)=                              12.57

Stack Velocity  (Actual, Feet/min)=                    3,846
Flow Rate (Actual, Cubic ft/min)=                     48,328
Flow rate (Standard, Wet, Cubic ft/min)=              30,959
Flow Rate (Standard, Dry, Cubic ft/min)=              18,974

Particulate Loading - Front Half

Particulate Weight (g)=                               0.0205     Corr. to 7% O2 & 12% CO2
Particulate Loading, Dry Std. (gr/scf)=               0.0064         0.0093      0.0106
Particulate Loading, Actual (gr/cu ft)=               0.0025
Emission Rate (lb/hr)=                                  1.04

No Back Half Analysis
```

```
                        * * METRIC UNITS * *
FILE NAME - 2twi06p3                                         PROG.=VER 06/27/89
RUN # - 3 - PARTICULATE/HCL TRAIN                            12-22-1989  20:23:57
LOCATION - Unit 4 Stack - TWI, Sauget, IL
DATE - 11/21/89
PROJECT # - 9304L-06-32

Initial Meter Volume (Cubic Meters)=              16.595
Final Meter Volume (Cubic Meters)=                18.073
Meter Factor=                                      1.079
Multiple leak checks, see end of printout                  Leak Correction=  0.0000
Net Meter Volume (Cubic Meters)=                   1.486
Gas Volume (Dry Standard Cubic Meters)=            1.396

Barometric Pressure (mm Hg)=                         755
Static Pressure (mm H2O)=                             -8

Percent Oxygen=                                     11.4
Percent Carbon Dioxide=                              7.2
Moisture Collected (ml)=                           661.2
Percent Water=                                      38.7

Average Meter Temperature (C)=                        37
Average Delta H (mm H2O)=                           14.5
Average Delta P (mm H2O)=                           19.2
Average Stack Temperature (C)=                       181

Dry Molecular Weight=                              29.61
Wet Molecular Weight=                              25.11

Average Square Root of Delta P (mm H2O)=          4.3685
% Isokinetic=                                      106.0

Pitot Coefficient=                                  0.83
Sampling Time (Minutes)=                           120.0
Nozzle Diameter (mm)=                               5.51
Stack Axis #1 (Meters)=                            1.219
Stack Axis #2 (Meters)=                            1.219
Circular Stack
Stack Area (Square Meters)=                        1.167

Stack Velocity  (Actual, m/min)=                   1,172
Flow rate (Actual, Cubic m/min)=                   1,368
Flow rate (Standard, Wet, Cubic m/min)=              877
Flow rate (Standard, Dry, Cubic m/min)=              537

Particulate Loading - Front Half

Particulate Weight (g)=                           0.0205    Corr. to 7% O2 & 12% CO2
Particulate Loading, Dry Std. (mg/cu m)=            14.6          21.4       24.4
Particulate Loading, Actual (mg/cu m)=               5.7
Emission Rate (kg/hr)=                              0.47

No Back Half Analysis
```

```
FILE NAME - 2twi06p3                                       PROG.=VER 06/27/89
RUN # - 3 - PARTICULATE/HCL TRAIN                          12-22-1989  20:24:23
LOCATION - Unit 4 Stack - TWI, Sauget, IL
DATE - 11/21/89
PROJECT # - 9304L-06-32

i   nt #       Delta P    Delta H    Stack T      Meter T
              (in. H20) (in. H20)     (F)     In(F)  Out(F)
 1             0.750      0.55       360        92      94
 2             0.680      0.50       358        96      90
 3             0.740      0.55       359        99      92
 4             0.740      0.65       359       102      94
 5             0.780      0.63       362       104      96
 6             0.870      0.68       362       104      96
 7             0.780      0.60       360       105      97
 8             0.850      0.63       360       106      98
 9             0.780      0.63       360       108      99
10             0.780      0.57       361       110     102
11             0.570      0.40       360       112     103
12             0.640      0.43       358       112     104
13             0.750      0.55       358       107     106
14             0.710      0.59       357       104     102
15             0.790      0.63       356       100      98
16             0.790      0.61       354        98      96
17             0.780      0.60       356        98      95
18             0.780      0.57       356        98      95
19             0.880      0.64       359        97      94
20             0.900      0.67       359        96      94
21             0.820      0.60       359        97      94
22             0.800      0.60       357        98      94
23             0.570      0.42       358        98      94
24             0.570      0.42       353        97      94


Fraction                 Final Wt.  Tare Wt.  Blank Wt.  Net Wt.
                            (g)        (g)       (g)       (g)
DRY CATCH                 0.0000     0.0000    0.0000    0.0000
FILTER                    4.4780     4.4709   -0.0002    0.0073

Fraction                 Final Wt.  Tare Wt.    Vol.     Net Wt.
                            (g)        (g)      (ml)       (g)
PROBE RINSE              68.4613    68.4473    108.0     0.0132
IMPINGERS                 0.0000     0.0000      0.0     0.0000
Probe Rinse Blank (mg/ml)=  0.0340  High Acetone Blank - Limit .0079
Impinger Blank (mg/ml)=  0.0000

Multiple leak checks used.  Final readings for each segment are listed below

Lk Rate (cfm) Time (min)
    0.0030    60.0000
    0.0000    60.0000
```

APPENDIX E

ANALYTICAL RESULTS FOR Cl, ASH, HHV, DENSITY, AND VISCOSITY

TABLE E-1. GENERAL WASTE FEED CHARACTERISTICS

	Feed rate (lb/h)	Kinematic viscosity (cSt)	HHV (Btu/lb)	Density (g/cc)	% Ash	% Total organic chlorine
High-grade organic waste						
Run 1	965	3.16	16,547	0.9314	0.024	10.96
Run 2	992	3.21	16,827	0.9311	0.039	11.05
Run 3	992	3.15	16,822	0.9311	0.041	9.35
Aqueous waste feed						
Run 1	491	1.43	270	1.0531	4.83	0.15
Run 2	501	1.46	738	1.0549	4.92	0.11
Run 3	508	1.48	697	1.0556	4.97	0.10
Drum solid feed						
Run 1	3,355	NDM	948	NDM	77.76	8.2
Run 2	3,503	NDM	785	NDM	78.16	10.98
Run 3	3,575	NDM	764	NDM	78.86	9.92
Bulk solid feed						
Run 1	14,131	NDM	33	NDM	85.50	2.75
Run 2	13,123	NDM	145	NDM	80.12	1.16
Run 3	12,636	NDM	56	NDM	79.91	1.65
Fuel oil						
Run 1	1,395	3.66	19,377	0.8537	0.096	NDM
Run 2	1,374	3.61	19,384	0.8565	0.041	NDM
Run 3	1,309	3.58	19,319	0.8570	0.045	NDM

NDM = Not determined.

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KNOXVILLE, TN 37950-1610

2323 SYCAMORE DR.
KNOXVILLE, TN 37921-1750

Combined Report

Mr. Paul Gorman
Midwest Research Institute
425 Volker Boulevard
Kansas City, Missouri 64110

December 29, 1989
(January 15, 1990)
Received: December 8th

Dear Mr. Gorman:

Enclosed are the corrected values of your results.

Sincerely yours,

GALBRAITH LABORATORIES, INC.

Gail R. Hutchens

Gail R. Hutchens
Exec. Vice-President

GRH:mck

LETTER AND SHIPMENTS BY U.S. MAIL · P.O. BOX 51610, KNOXVILLE, TN 37950-1610. OTHER CARRIERS · 2323 SYCAMORE DR. KNOXVILLE, TN 37921-1750
ESTABLISHED 1950

page 1
Mr. Gorman
December 29, 1989
(January 15, 1990)

Your #.	Our #.	% Total Chlorine.	% Inorganic Chloride,	% Total Organic Chlorine.
1027	J-0815	10.96	< 0.1	10.96
2027	J-0816	11.05	< 0.1	11.05
3027	J-0817	9.35	< 0.1	9.35
4027	J-0818	9.41	< 0.1	9.41
5027	J-4176 (J-0819)	18.10	0.33	17.77
5028	J-5277 (J-0847)	21.61		
6027	J-4177** (J-0820)	21.33	< 0.1	21.33
6028	J-5273 (J-0848)	18.60		
7027	J-5471 (J-0821)	18.63	0.54	18.09
7028	J-5274 (J-0849)	17.11		
8027	J-5629** (J-0822)	18.58	0.62	17.96
8028	J-5275 (J-0850)	19.84		
1087	J-0823	4.34	4.19	0.15
2087	J-0824	4.28	4.17	0.11
3087	J-0825	4.22	4.12	0.10
4087	J-0826	5.91	4.84	1.07
5087	J-0827	5.90	4.66	1.24
6087	J-0828	5.63	4.85	0.78
7087	J-0829	5.07 5.31	4.83 4.90	0.24 0.41

High Grade Liquid
Organic Waste

VOA Composite (xx027)
Core Composite (xx028)

Aqueous Waste
VOA Composite

**Due to minimal headspace in sample vials, previous efforts to mix samples apparently failed. Enclosed is procedure #G-25A which was followed in the re-analysis of these samples.

page 2
Mr. Gorman
December 29, 1989
(January 15, 1990)

Your #,	Our #.	% Total Chlorine,	% Inorganic Chloride,	% Total Organic Chlorine,	
8087	J-0830	4.91	4.90	0.01	
5117	J-0831	21.60	0.14	21.46	
6117	J-0832	27.45	0.09	27.36	Sludge Waste Feed
7117	J-0833	26.58 26.85	0.12 0.12	26.46 26.73	
8117	J-0834	24.12	< 0.1	24.12	
1146	J-0835	0.29	0.38	< 0.1	
2146	J-0836	0.28	0.36	< 0.1	
3148	J-0837	0.31	0.32	< 0.1	
4148	J-0838	0.29	0.36	< 0.1	[illegible]
5146	J-0839	0.25	0.38	< 0.1	
6148	J-0840	0.25	0.28	< 0.1	
7146	J-0841	0.35 0.39	0.53 0.55	< 0.1 < 0.1	
8148	J-0842	0.32	0.41	< 0.1	

Your #,	Our #,	BTU/lb,	% Ash,	Density g/ml,	Kinematic Viscosity Centistokes.	
1028	J-0843	16547	0.024	0.9314	3.16	
2028	J-0844	16827	0.039	0.9311	3.21	
3028	J-0845	16822	0.041	0.9311	3.16	
4028	J-0846	16528	0.025	0.9311	3.26	-gn Grade
5028	J-0847	13348	0.037	0.9603	4.30	Liquid Organic Waste
6028	J-0848	13535	0.132	0.9743	2.40	
7028	J-0849	13210 13260	0.063 0.074	0.9756 0.9755	3.24 3.19	
8028	J-0850	13588	0.067	0.9773	2.99	
1088	J-0851	270	4.83	1.0531	1.43	
2088	J-0852	738	4.92	1.0549	1.46	
3088	J-0853	697	4.97	1.0556	1.48	
4088	J-0854	491	5.98	1.0671	1.53	
5088	J-0855	499	5.99	1.0681	1.51	Aqueous Waste
6088	J-0856	338	5.97	1.0671	1.53	
7088	J-0857	519 439	5.98 6.04	1.0681 1.0681	1.53 1.53	
8088	J-4175 (J-0858)	5279 5099	5.20 5.81	1.0581	2.52	
8087	J-5472 (J-0830)	520				
1121	J-0859	19377	0.096	0.8537	3.66	
2121	J-0860	19384	0.041	0.8565	3.61	
3121	J-0861	19319	0.045	0.8570	3.58	Fuel Oil
4121	J-0862	19322	*	0.8505	3.11	
5121	J-0863	19382	< 0.002	0.8535	3.24	

* The sample was broken and lost before we could complete the ash determination.

Your #,	Our #,	BTU/lb,	% Ash,	Density g/ml,	Kinematic Viscosity Centistokes,
6121	J-0864	19300	< 0.002	0.8573	3.30
7121	J-0865	19382 19406	< 0.002 < 0.002	0.8496 0.8495	3.02 3.01
8121	J-0866	19335	< 0.002	0.8527	3.22
5118	J-0867	4482	1.23		
6118	J-0868	5164	3.17		
7118	J-4174 (J-0869)	327 485 463	5.89 5.87 5.87		
7117	J-5473 (J-0833)	4949			
8118	J-0870	5164	3.92		

Sludge
Waste
Feed

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Mr. Gorman
December 29, 1989
(January 15, 1990)

Your #,	Our #,	% Chlorine (Total),	% Inorganic Chloride,	% Total Organic Chlorine,	BTU/ pound,	% Ash,	
1126	J-4166* (J-0871)	8.20	< 0.05	8.20	943	77.76	
2126	J-4167* (J-0872)	10.98	< 0.05	10.98	785	78.16	
3126	J-4168* (J-0873)	9.92	< 0.06	9.92	764	78.86	Dry Solids
4126	J-4169* (J-0874)	9.13	< 0.05	9.13	956	74.27	
5126	J-4170* (J-0875)	13.72 14.12	< 0.05	13.72 14.12	2392	77.95	
6126	J-4171* (J-0876)	10.72	< 0.05	10.72	627	71.12	
7126	J-4172* (J-0877)	14.77	< 0.05 < 0.05	14.77	1447 998 1390	67.18 64.60	
8126	J-4173* (J-0878)	13.43	0.02	13.41	613	73.49	
1136	J-0879	2.75	< 0.02	2.75	33	85.50	
2123	J-0880	2.05	< 0.03	2.05	300 None found	79.89	Bulk Solids
2136	J-0881	1.16	< 0.02	1.16	145	80.12	
3136	J-0882	1.65	< 0.02	1.65	56	79.91	

*Based on ground sample.

Your #,	Our #,	% Chlorine, (Total)	% Inorganic Chloride,	% Total Organic Chlorine,	BTU/lb.	% Ash.
4136	J-0883	2.11	< 0.02	2.11	220	84.63
5136	J-0884	2.23	0.04	2.19	215	79.06
6136	J-0885	3.32	0.05	3.27	1091	75.71
7136	J-0886	3.61	0.02	3.59	250	78.74
		2.74	0.02	2.72	66	83.67
					125	
8136	J-0887	5.15	< 0.03	5.15	214 None Found	80.60

Your #,	Our #,	mg/liter Chloride,	pH,
1174	J-0888	246	2.20
2174	J-0889	125	2.46
3174	J-0890	155	2.35
4174	J-0891	157	2.35
5174	J-0892	40.1	2.94
6174	J-0893	117	2.48
7174	J-0894	116	2.46
		137	2.47
8174	J-0895	149	2.37

M5 Condensate

1175	J-0896	0.40	8.79
2175	J-0897	1.06	8.99
3175	J-0898	< 0.3	8.87
4175	J-0899	< 0.3	8.79
5175	J-0900	0.79	8.59
		0.66	
6175	J-0901	0.49	8.78

M5 NaOH #1

Your #,	Our #,	mg/liter Chloride,	pH,	% Chloride,	
7175	J-0902	0.60 0.46	8.68 8.70		
8175	J-0903	< 0.3	8.81		
1177	J-0904	< 0.3	8.86		
2177	J-0905	0.86	8.71		
3177	J-0906	< 0.3	8.67		
4177	J-0907	0.91	8.69		M5 NaOH #2
5177	J-0908	< 0.3	8.85		
6177	J-0909	< 0.3	8.63		
7177	J-0910	< 0.3 < 0.3	8.83 8.86		
8177	J-0911	< 0.3	8.67		
1221	J-0912		0.11	2.41	
2221	J-0913		0.29	1.43	M5 SDA Condensate
3221	J-0914		0.14	3.02	
2190	J-0915	9.04	6.40		M5 H2O Blank
2192	J-0916	3.83	12.69		M5 NaOH Blank

Your #,	Our #,	% Total Chlorine,	% Inorganic Chloride,	% Total Organic Chlorine,	
5208	J-0917	< 0.0009	< 0.0001	< 0.0009	
5209	J-4178 (J-0918)	4.38	< 0.01	4.38	Audit Sample, Organic Cl
5210	J-4179 (J-0919)	8.69	< 0.01	8.69	

Your #,	Our #,	% Ash,	% mg/liter Chloride,
5205	J-0920	0.01	
5206	J-0921	1.94	
5207	J-0922	4.56	
5201	J-0923		< 0.3
5202	J-0924		96
5203	J-0925		927

Audit Samples
Ash

Audit Samples
Cl$^-$ by ion chromatography

Sincerely yours,

GALBRAITH LABORATORIES, INC.

Gail R. Hutchens /ox
Gail R. Hutchens
Exec. Vice-President

GRH:mck

Galbraith Laboratories, Inc.

Method Summary

Procedure #: G-25A Analyte: ___ Range: ___

Title: Homogenizing Liquid Samples - Simple Mixing

Effective Date: January 15, 1990 Superseded:

Preparation:

Liquid samples will be thoroughly shaken with swirling before sampling whether or not visible particulate matter is present.

When samples are received filled to "no headspace" specifications all sample material must be transferred to a larger, thoroughly-cleaned container to effect sufficient agitation to mix the sample. After sampling, the material will be returned to the original container for storage.

If phase separation occurs before sampling can be completed, see supervisor.

References:

Shugar, G.J., and Dean, J.A., The Chemist's Ready Reference Book, McGraw-Hill, New York, 1990.

APPENDIX F

METALS ANALYSIS RESULTS

F.1 Waste Feed Characteristics

The bulk solid and unspiked drum solid waste feeds were analyzed to determine the concentration of 10 metals (Ag, As, Ba, Be, Cd, Cr, Hg, Pg, Sb, and Tl). Analyses of the high-grade liquid organic waste and the fuel oil for metals was not attempted due to difficulties encountered when using method SW 3040 to analyze for metals in organics for previous trial burns. It can be assumed that the potential metals level in these feeds are negligible compared to the quantities spiked into the solid wastes. Tables F-1 through F-3 present the metals concentrations in each of the analyzed waste feeds used during each run. The individual metal input rate totals for the three metal sources do not include any of the values that were below the detection limits. That is, the values below detection limits were assumed to be zero so that the totals represent amounts actually found. Also included are the number of metal spike containers fed during the MM5 metals train sampling period.

F.2 Multiple Metals Sampling Trains Test Data

The four portions of the multiple metals sampling trains which were analyzed for metals were:

1. Cyclone catch and rinses (SDA inlet sampling train only)
2. Filter and probe rinse residue
3. Condensate and nitric acid/peroxide impingers (back half)
4. Potassium permanganate/sulfuric acid impinger

Analysis results for the three components of the stack emission sampling train are shown in Table F-4. The totals shown for the three components do not include any of the values that were below detection limits. That is, the values below detection limits were assumed to be zero, so that the totals represent amounts actually found. An exception to this is when all the component analyses were below the detection limits, a "less than" value is reported.

TABLE F-1. RUN 1 METALS CONCENTRATIONS IN FEEDS AND INPUT RATES

	Metal concentration									
Component	Ag (ug/g)	As (ug/g)	Ba (ug/g)	Be (ug/g)	Cd (ug/g)	Cr (ug/g)	Hg (ug/g)	Pb (ug/g)	Sb (ug/g)	Tl (ug/g)
Drum solids	< 30	4.69	35.8	< 0.20	2.0	20	< 2	44.7	< 300	< 200
Bulk solids	< 20	4.66	36.9	< 0.08	< 0.6	18	1	37	< 200	< 100

	Feed rate		Metals input rate									
Component	(lb/h)	(g/min)	Ag (g/min)	As (g/min)	Ba (g/min)	Be (g/min)	Cd (g/min)	Cr (g/min)	Hg (g/min)	Pb (g/min)	Sb (g/min)	Tl (g/min)
Drum solids	3,355	25,400	< 0.76	0.12	0.91	< 0.005	0.051	0.51	< 0.06	1.14	< 7.62	< 5.08
Bulk solids	14,131	107,000	< 2.14	0.50	3.95	< 0.008	< 0.06	1.93	0.11	3.96	< 21.4	< 10.7
Metals spike[a]	5 containers		5.66	0.38	0.19	0.005	0.57	0.94	0.06	0.28	7.55	
		Total =	5.66	1.00	5.05	0.005	0.62	3.38	0.17	5.38	7.55	ND

ND = not determined.

[a] Metals spike did not contain thallium (Tl).

TABLE F-2. RUN 2 METALS CONCENTRATIONS IN FEEDS AND INPUT RATES

	Metal concentration									
Component	Ag (ug/g)	As (ug/g)	Ba (ug/g)	Be (ug/g)	Cd (ug/g)	Cr (ug/g)	Hg (ug/g)	Pb (ug/g)	Sb (ug/g)	Tl (ug/g)
Drum solids	< 30	4.89	42.6	< 0.20	2.0	25.0	< 0.8	55.7	< 200	< 100
Bulk solids	< 20	5.22	140	< 0.10	< 0.7	20	< 0.6	43.8	< 200	< 200

	Feed rate		Metals input rate									
Component	(lb/h)	(g/min)	Ag (g/min)	As (g/min)	Ba (g/min)	Be (g/min)	Cd (g/min)	Cr (g/min)	Hg (g/min)	Pb (g/min)	Sb (g/min)	Tl (g/min)
Drum solids	3,503	26,483	< 0.79	0.129	1.12	< 0.005	0.05	0.66	< 0.02	1.47	< 5.29	< 2.64
Bulk solids	13,123	99,210	< 1.98	0.518	13.9	< 0.009	< 0.06	1.98	< 0.06	4.35	< 19.8	< 19.8
Metals spike[a]	5 containers		5.66	0.38	0.19	0.005	0.57	0.94	0.06	0.28	7.55	
		Total =	5.66	1.03	15.2	0.005	0.62	3.58	0.06	6.10	7.55	ND

ND = not determined.

[a] Metals spike did not contain thallium (Tl).

TABLE F-3. RUN 3 METALS CONCENTRATIONS IN FEEDS AND INPUT RATES

	Metal concentration									
Component	Ag (ug/g)	As (ug/g)	Ba (ug/g)	Be (ug/g)	Cd (ug/g)	Cr (ug/g)	Hg (ug/g)	Pb (ug/g)	Sb (ug/g)	Tl (ug/g)
Drum solids	< 30	5.03	39.5	< 0.2	2	20	< 0.7	47.4	< 200	< 200
Bulk solids	< 30	5.89	153	< 0.2	< 1	20	< 0.8	56.8	< 300	< 200

	Feed rate		Metals input rate									
Component	(lb/h)	(g/min)	Ag (g/min)	As (g/min)	Ba (g/min)	Be (g/min)	Cd (g/min)	Cr (g/min)	Hg (g/min)	Pb (g/min)	Sb (g/min)	Tl (g/min)
Drum solids	3,575	27,027	< 0.81	0.14	1.07	< 0.005	0.054	0.54	< 0.02	1.28	< 5.41	< 5.40
Bulk solids	12,636	95,528	< 2.87	0.56	14.61	< 0.02	< 0.095	1.91	0.08	5.43	< 28.66	< 19.1
Metals spike[a]	8 containers		9.07	0.60	0.30	0.008	0.91	1.51	0.09	0.45	12.08	
		Total =	9.07	1.30	16.0	0.008	0.96	3.96	0.09	7.16	12.08	ND

ND = not determined.

[a] Metals spike did not contain thallium (Tl).

TABLE F-4. ANALYSIS RESULTS FOR STACK MM5-M (METALS) TRAIN
(micrograms)

	Ag	As	Ba	Be	Cd	Cr	Hg	Pb	Sb	Tl
Run 1										
Filter and probe rinse	< 7	0.45	7.19	0.05	4.5	17	2	13	< 40	< 30
Back half	< 20	< 0.09	24.7	< 0.1	0.8	< 7	110	4.62	< 30	< 20
$KMnO_4$ impinger	NA	NA	NA	NA	NA	NA	10	NA	NA	NA
Total (ug)	< 27	0.45	31.9	0.05	5.3	17	122	18	< 70	< 50
Total (ug/dscm)[a]	< 18	0.30	21.0	0.03	3.5	11	80.5	12	< 50	< 30
Total (g/min)[b]	< 0.009	0.00015	0.0107	0.00002	0.0018	0.0056	0.041	0.0061	< 0.03	< 0.02
Run 2										
Filter and probe rinse	< 7	0.67	17.1	0.24	5.0	98.1	2.0	23	< 40	< 30
Back half[c]	< 500	< 3	< 20	< 3	< 20	< 200	480	< 6	< 700	< 500
$KMnO_4$ impinger	NA	NA	NA	NA	NA	NA	10	NA	NA	NA
Total (ug)	< 507	0.67	17.1	0.24	5.0	98.1	492	23	< 740	< 530
Total (ug/dscm)[a]	< 316	0.42	10.6	0.15	3.1	61.1	307	14	< 460	< 330
Total (g/min)[b]	< 0.2	0.00023	0.00570	0.000081	0.0017	0.0329	0.165	0.0075	< 0.2	< 0.2
Run 3										
Filter and probe rinse	< 7	1.30	20.1	0.39	5.6	38.1	< 0.6	23	< 40	< 30
Back half	< 20	< 0.09	3.3	< 0.09	0.9	< 7	360	2.87	< 30	< 20
$KMnO_4$ impinger	NA	NA	NA	NA	NA	NA	78.9	NA	NA	NA
Total (ug)	< 27	1.30	23.4	0.39	6.5	38.1	439	26	< 70	< 50
Total (ug/dscm)[a]	< 16	0.774	13.9	0.23	3.9	22.7	261	15	< 40	< 30
Total (g/min)[b]	< 0.009	0.000426	0.0076	0.000126	0.0021	0.0125	0.144	0.0083	< 0.02	< 0.02
Blank train										
Filter and probe rinse	< 6	0.3	18.0	< 0.04	1	9.5	< 0.6	3.06	< 30	< 30
Back half	< 20	< 0.1	2.8	< 0.2	< 0.8	< 8	2	2.3	< 40	< 30
$KMnO_4$ impinger	NA	NA	NA	NA	NA	NA	< 8	NA	NA	NA
Total (ug)	< 26	0.3	20.8	< 0.24	1	9.5	2	5.4	< 70	< 60

---

[a] Gas volumes sampled in each run were 1.516, 1.605, and 1.679 dscm, respectively.

[b] Stack flow rates in each run were 509, 538, and 550 dscm/min, respectively.

[c] Higher detection limits in Run 2 were caused by additional dilutions performed during analysis. These dilutions eliminated spectral interferences observed during initial analysis trials.

Data on the total amount of metal found in each train indicate that mercury was present at significantly higher quantities and chromium and cadmium were present at slightly higher quantities in the sample train than in the blank train. For the remaining metals the quantities found in the sample train were not significantly different than in the blank.

Analysis results for the four components of the SDA inlet gas sampling train are shown in Table F-5. During run 2 the filter in the SDA sampling train was replaced with a fresh filter. Both filters were subsequently analyzed for metals. The analysis results are given for each filter. The totals do not include any of the values that are below detection limits. An exception to this is that when all components analyzed were below the detection limit, a "less than" value is reported. Data on the total amount of each metal found in each train indicate that all metals, except for thallium, which was always below the detection limit, were present at significantly higher quantities in the sample trains than in the blank train (blank train results are included in Table F-4).

F.3 Reanalysis of SDA Cyclone Catch

F.3.1 Procedure

The remaining samples from the MM5 front half acetone rinse and cyclone catch for Runs 1, 2, and 3 were reanalyzed including treatment with concentrated HCl, to determine Ag content. The acetone rinse and cyclone catch from each run had been combined for the particulate weight determination that was performed prior to any metals analysis. This portion of the samples (excluding the filter) represented most of the particulate matter that had been collected in the MM5 train. Two 0.5-g samples from each run were digested with concentrated HNO_3 and HF according to the draft metals protocol. One of these two then also had concentrated HCl added to it and was slightly heated again. Both then had boric acid added to them followed by dilution with water (2½ mL HCl per 50 mL of the final diluted solution). These diluted solutions were then analyzed for Ag using a Jarrell-Ash Model 1155A inductively coupled argon plasma atomic emission spectrometer.

TABLE F-5. ANALYSIS RESULTS FOR SDA INLET (METALS) TRAIN
(data in micrograms)

	Ag	As	Ba	Be	Cd	Cr	Hg	Pb	Sb	Tl
Run 1										
Dry catch and acetone rinse	4,180[c]	1,390	12,100	125	1,110	5,300	120	8,500	12,000	< 2,000
Filter and probe rinse	100	701	75.2	10.8	3,460	770	6.3	21,600	3,720	< 200
Back half	< 2,000	< 9	< 60	< 10	< 70	< 700	477	< 30	< 3,000	< 2000
$KMnO_4$ impinger	NA	NA	NA	NA	NA	NA	< 10	NA	NA	NA
Total (ug)	4,280	2,091	12,175	136	4,570	6,070	603	30,100	15,720	< 4,200
Total (ug/dscm)[a]	1,780	870	5,069	56.6	1,900	2,530	251	12,500	6,540	< 1,700
Total (g/min)[b]	0.76	0.37	2.16	0.0242	0.811	1.08	0.107	5.34	2.79	< 0.7
Run 2										
Dry catch and acetone rinse	3,300[c]	4,830	18,800	86	900	9,420	160	7,800	7,000	< 4,000
Filter and probe rinse	< 60	142	72.3	4.62	451	4,630	7.89	3,030	700	< 300
Second filter	300	580	10	< 3	2,740	338	NA	17,800	1,700	500
Back half	< 200	46.2	67.6	< 0.9	184	3,660	399	750	400	< 200
$KMnO_4$ impinger	NA	NA	NA	NA	NA	NA	< 9	NA	NA	NA
Total (ug)	3,600	5,600	18,900	91	4,280	18,000	567	29,400	9,800	500
Total (ug/dscm)[a]	1,720	2,680	9,040	44	2,050	8,600	271	14,100	4,690	240
Total (g/min)[b]	0.74	1.15	3.88	0.019	0.879	3.69	0.116	6.05	2.01	0.10
Run 3										
Dry catch and acetone rinse	4,800[c]	1,160	15,100	164	1,060	6,280	74	4,600	10,000	< 1,000
Filter and probe rinse	60	1,150	60.1	14.2	3,770	897	12.9	11,600	5,360	< 200
Back half	< 20	2.20	3.7	< 0.1	2	< 7	497	3.80	373	< 20
$KMnO_4$ impinger	NA	NA	NA	NA	NA	NA	< 9	NA	NA	NA
Total (ug)	4,860	2,310	15,200	178	4,830	7,180	584	16,200	15,700	< 1,220
Total (ug/dscm)[a]	2,280	1,080	7,140	83.6	2,270	3,370	274	7,610	7,370	< 573
Total (g/min)[b]	0.91	0.431	2.85	0.0334	0.906	1.34	0.109	3.04	2.94	< 0.2

[a] Gas volumes sampled in each run were 2.402, 2.091, and 2.130 dscm, respectively.

[b] Stack flow rates in each run were 427, 429, and 399 dscm/min, respectively.

[c] Revised value from reanalysis of cyclone catch.

NA = not analyzed.

F.3.2 Results

Results of the reanalysis, with and without the addition of concentrated HCl, are given in Table F-6. These results are expressed as total µg, representing the total amount in the original MM5 dry catch/acetone rinse portion of the sampling train, rather than the amount in the aliquot that was analyzed. These results clearly show that the samples treated with concentrated HCl yielded much larger values (10X-20X) for the amount of Ag present in the samples.

The reanalysis also included spiking of a sampling from Run 2 with Ag (as $AgNO_3$). Ag recovery was very low (8%) for the aliquot not treated with HCl, but was still only 44% for the aliquot that was treated with HCl.

The revised values for the Ag input rate determined at the SDA inlet (g/min) were compared with silver feed rates in the drum feed, as given in Table 4-5. This comparison is provided in Table F-7, along with the comparisons for the other metals. These comparisons indicate that the rate for Ag at the SDA inlet was 10% to 13% of the input rate in the drum feed. Most of the other metals were higher, ranging from 18% to over 100%. This suggests that the amount of concentrated HCl used in the reanalysis procedure was not totally effective in redissolving AgCl. However, it certainly was at least partially effective, and yielded much higher values for Ag than the specified procedure that does not include concentrated HCl. This conclusion is also supported by the spike recovery data mentioned above.

F.3.3 Conclusions

These reanalyses results provide evidence that the draft procedure for determining metals emissions (MM5) yielded low results for Ag for this test. It is suspected that the low results are related to situations where the gas stream being sampled contains significant amounts of HCl (e.g., incinerators burning chlorinated wastes) leading to formation of AgCl that is difficult to solubilize for analysis. It can also be concluded that additional treatment with concentrated HCl significantly increases the amount of silver recorded from the samples. However, the amount of concentrated HCl used in the

TABLE F-6. RESULTS FROM THE Hg REANALYSIS OF THE COMBINED DRY CATCH/ACETONE RINSE SAMPLES (SDA INLET) WITH AND WITHOUT HCl ADDITION

	Amount of Hg found in sample (µg)	
	Without HCl	With HCl
Run 1	< 300	4,180
Run 2	< 300	3,300
Run 3	< 300	4,800

TABLE F-7. COMPARISON OF METAL FEED RATES AND SDA INLET RATES

Metal	Feed rate (g/min)	SDA inlet rate (g/min)	SDA inlet/feed rate %
Run 1			
Silver	5.56	0.76	13
Arsenic	1.00	0.437	44
Barium	5.05	2.16	43
Beryllium	0.005	0.00242	48
Cadmium	0.62	0.811	130
Chromium	3.38	1.08	32
Mercury	0.17	0.107	63
Lead	5.38	5.34	99
Antimony	7.55	2.79	37
Thallium	ND	<0.7	-
Run 2			
Silver	5.66	0.74	13
Arsenic	1.03	1.15	112
Barium	15.2	3.88	26
Beryllium	0.005	0.019	380
Cadmium	0.62	0.879	142
Chromium	3.58	3.69	103
Mercury	0.06	0.116	190
Lead	6.10	6.05	99
Antimony	7.55	2.01	27
Thallium	ND	0.10	-
Run 3			
Silver	9.07	0.91	10
Arsenic	1.30	0.421	33
Barium	16.0	2.85	18
Beryllium	0.008	0.0334	418
Cadmium	0.96	0.906	94
Chromium	3.96	1.34	34
Mercury	0.09	0.109	121
Lead	7.16	3.04	42
Antimony	12.08	2.94	24
Thallium	ND	<0.2	-

reanalysis of these samples had not been optimized, and may not have been sufficient for effective solubilization of the Ag, as evidenced by the comparison with input rates discussed previously and by the low spike recovery of 44%.

Use of the HCl for recovery of Ag presents the complication of precluding analysis for some other metals by GFAA (e.g., Pb and As). HCl forms volatile chlorides of Pb and As that would not be detected in the GFAA analysis. Splitting of samples for analysis is possible, but would be difficult, since the samples are solids (normally on the MM5 filter) and the initial digest solution contains undissolved solids including AgCl.

In summary, these results indicate that further development work is needed on the analysis procedure for MM5 samples, to provide accurate results for Ag, especially when the gas stream contains HCl.

F.4 Metals Analysis of Baghouse/Spray Dryer Residual and Lime Slurry

The baghouse/spray dryer residual and lime slurry were also analyzed for the 10 toxic metals. To calculate the flow rate of metal in and out of the baghouse/spray dryer system the analyses results were multiplied by the mass rate of lime slurry and residual, respectively. These results are shown in Table F-8.

TABLE F-8. METALS ANALYSIS RESULTS OF BAGHOUSE/SPRAY DRYER RESIDUAL AND LIME SLURRY

	Baghouse/Spray Dryer Residual					
	Run 1		Run 2		Run 3	
Metal	ug/g	g/min	ug/g	g/min	ug/g	g/min
Ag	22	0.61	50	1.4	48	1.3
As	3.11	0.086	11.4	0.33	11.5	0.32
Ba	17.4	0.48	26.1	0.75	39.1	1.1
Be	< 0.2	< 0.006	< 0.2	< 0.006	0.75	0.021
Cd	5.8	0.16	11	0.31	10.7	0.29
Cr	26	0.72	42	1.2	35	0.96
Hg	2	0.06	< 0.9	< 0.026	0.7	0.02
Pb	72	2.0	190	5.4	130	3.6
Sb	< 200	< 6	< 300	< 9	< 200	<5
Tl	< 200	< 6	< 200	< 6	< 200	<5

The residual output rate was approximated as the rate of lime in plus the difference in the particulate rate in and the particulate rate out of the SDA. 27,790, 28,581, and 27,460 g/min were calculated as the residual output rates for Run 1, 2, and 3 respectively.

	Lime Slurry					
	Run 1		Run 2		Run 3	
Metal	ug/g	g/min	ug/g	g/min	ug/g	g/min
Ag	< 10	< 1	< 9	< 1	< 9	< 1
As	< 0.05	< 0.006	0.06	0.007	0.09	0.01
Ba	1.4	< 0.17	1.1	0.13	1.1	0.13
Be	< 0.06	< 0.007	< 0.05	< 0.006	< 0.05	0.006
Cd	< 0.4	< 0.05	0.4	0.05	0.4	0.05
Cr	< 4	< 0.5	5	0.6	6	0.7
Hg	1	0.1	< 0.3	< 0.04	< 0.3	< 0.03
Pb	< 0.2	< 0.02	< 0.2	< 0.02	0.1	0.01
Sb	< 20	< 2	< 20	< 2	< 20	< 2
Tl	< 20	< 2	< 20	< 2	< 20	< 2

Lime slurry input rates were 118,000, 119,000, and 116,000 g/min for Runs 1, 2, and 3 respectively.

TABLE 4

LIST OF SAMPLES FOR METALS ANALYSIS

	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8	Blank Tr (11/28/89)
4A. Drum Solids									
Composite	01127	02127	03127	-----					
4B. Bulk solids									
Composite	01137	02128 02137	03137	-----					
4C. MM5-M (Stack)									
FH acetone*	01151	02151	03151						15151
FH HNO_3	01152	02152	03152						15152
Filter*	01153	02153	03153						15153 (Filter No. 135)
Cond. & HNO_3/H_2O_2	01154	02154	03154						15154
$KMnO_4$	01155	02155	03155						15155
4D. MM5-MI (Inlet)									
Dry catch*	01223	02223	03223						
FH acetone*	01216/ 01222	02216/ 02222	03216 03222						
FH HNO_3	01217	02217	03217						
Filter*	01218	02218/ 02224	03218						
Cond. & HNO_3/H_2O_2	01219	02219	03219						
$KMnO_4$	01220	02220	03220						

* Particulate weight to be determined prior to metals analysis.

4E. Other MM5-M Blanks (no analysis necessary unless problems occur)

Acetone Blank	02183
HNO_3 Blank	02187
H_2O Blank	02188
HNO_3/H_2O_2 Blank	02194
$KMnO_4$ Blank	02195
Filter Blank	02197

1145/2145/3145 SDA Residues
~~46~~
1146/2146/3146 Lime Slurry

Table [illegible]. Sample Analysis Results.

Project Nos: 9102L5721 9304L.ocl
Lotus File: 12148P
Analysts: M. DeBord, E. Swaffar, J. Haug, G. Dewalt, E. McClendon
Analysis Dates: 12-14, 16, 18-89, 1-2, 4, 8, 9, 11-90
Analytes: (see below)

Data Analyst: E. McClendon
Date: 1-1[illegible]-90

Sample Analysis Results:
Note: NA = Not Analyzed.
Verified by: EDM 2-7-90

Sample Number	ASF Bar Code(s)	Sample Units	Element Ag	Element As	Element Ba	Element Be	Element Co
01127	19414	ug/g	<30	4.69	35.8	<0.2	2
01137	19415	ug/g	<20	4.66	36.9	<0.08	<0.6
01145	19430	ug/g	22	3.11	17.4	<0.2	5.8
01146	19431	ug/g	<10	<0.05	1.4	<0.06	<0.4
01151/01152/01153	19447	ug	<7	0.45	7.19	0.05	4.5
01154	19406	ug	<20	<0.09	24.7	<0.1	0.8
01155		ug	NA	NA	NA	NA	NA *
~~01216/01222/[illegible]~~	~~[illegible]~~	~~ug~~	~~<500~~	~~1450~~	~~12700~~	~~[illegible]~~	~~1170~~
01217/01218	19448	ug	100	701	75.2	10.8	3460
01219	19407	ug	<2000	<9	<60	<10	<70
01220		ug	NA	NA	NA	NA	NA
02127	19416/19417	ug/g	<30	4.39	42.6	<0.2	2
02128	19424/19425	ug/g	<20	5.39	151	<0.1	<0.7
02137	19420/19421	ug/g	<20	5.05	128	<0.1	1
02145	19432/19433	ug/g	50	11.4	26.1	<0.2	11
02146	19436/19437	ug/g	<9	0.06	1.1	<0.05	0.4
02151/02152/02153	19450	ug	<7	0.67	17.1	0.24	5.0
02154	19408	ug	<500	<3	<20	<3	<20
02155		ug	NA	NA	NA	NA	NA
~~02216/[illegible]~~	~~19452~~	~~ug~~	~~2000~~	~~[illegible]~~	~~20000~~	~~92~~	~~960~~ *
02217/02218	19451	ug	<60	142	72.3	4.62	451
02219	19409	ug	<200	46.2	67.6	<0.9	184
02220		ug	NA	NA	NA	NA	NA
03127	19428	ug/g	<30	5.03	39.5	<0.2	2
03137	19429	ug/g	<30	5.89	153	<0.2	<1
03145	19440	ug/g	46	11.5	39.1	0.75	10.7
03146	19441	ug/g	<9	0.09	1.1	<0.05	0.4
03151/03152/03153	19453	ug	<7	1.30	20.1	0.39	5.6
03134	19410	ug	<20	<0.09	3.3	<0.09	0.9
03155		ug	NA	NA	NA	NA	NA
~~03216/[illegible]~~	~~19455~~	~~ug~~	~~<400~~	~~[illegible]~~	~~13800~~	~~171~~	~~[illegible]~~ *
03217/03218	19454	ug	60	1150	60.1	14.2	3770
03219	19411	ug	<20	2.20	3.7	<0.1	2
03220		ug	NA	NA	NA	NA	NA
15151/15152/15153	19464	ug	<6	0.3	18.0	<0.04	1
15154	19412	ug	<20	<0.1	2.8	<0.2	<0.8
15155		ug	NA	NA	NA	NA	NA

* Data to be updated
EDM 4-10-90

Comments:
These samples were analyzed on a Jarrell-Ash Model 1155A ICP-AES, a Perkin-Elmer Model 5000 Zeeman atomic absorption spectrometer, a Perkin-Elmer Model 3030B atomic absorption spectrometer and a GBC Model 902 atomic absorption spectrometer.
The sample results are as received, in units as listed.

Table 1. Sample Analysis Results (Continued).

Project Nos: 9102L5721 9704L0661 Data Analyst: E. McClendon
Lotus File: 121489 Date: 1-16-90
Analysts: M. DeBord. S. Swaffar. J. Haug. G. Dewalt. E. McClendon
Analysis Dates: 12-14. 15. 18-89. 1-2. 4. 8. 9. 11-90
Analytes: (see below)

Sample Analysis Results:
Note: NA = Not Analyzed.
Verified by: ELM 2-7-90

Sample Number	ASF Bar Code(s)	Sample Units	Element Cr	Element Hg	Element Pb	Element Sb	Element Tl
01127	19414	ug/g	20	<2	44.7	<300	<200
01137	19415	ug/g	18	1	37	<200	<100
01145	19430	ug/g	26	2	72	<200	<200
01146	19431	ug/g	<4	1	<0.2	<20	<20
01151/01152/01153	19447	ug	17	2	13	<40	<30
01154	19406	ug	<7	110	4.62	<30	<20
01155		ug	NA	10	NA	NA	NA
~~[illegible]~~	~~[illegible]~~	~~ug~~	~~[illegible]~~	130	~~2700~~	~~13000~~	~~2000~~ # Data to be updated ELM 4-10-90
01217/01218	19448	ug	770	6.3	21600	3720	<200
01219	19407	ug	<700	477	<30	<3000	<2000
01220		ug	NA	<10	NA.	NA	NA
02127	19416/19417	ug/g	25	<0.8	55.7	<200	<100
02128	19424/19425	ug/g	19	<0.6	41.3	<200	<200
02137	19420/19421	ug/g	22	<0.6	46.3	<300	<200
02145	19432/19433	ug/g	42	<0.9	190	<300	<200
02146	19436/19437	ug/g	5	<0.3	<0.2	<20	<20
02151/02152/02153	19450	ug	98.1	2.0	23	<40	<30
02154	19408	ug	<200	480	<6	<700	<500
02155		ug	NA	10	NA	NA	NA
~~02216/[illegible]~~	~~19452~~	~~ug~~	~~10000~~	170	~~3200~~	~~7000~~	~~<4000~~ *
02217/02218	19451	ug	4630	7.89	3030	700	<300
02219	19409	ug	3660	399	790	400	<200
02220		ug	NA	<9	NA	NA	NA
03127	19428	ug/g	20	<0.7	47.4	<200	<200
03137	19429	ug/g	20	<0.8	56.8	<300	<200
03145	19440	ug/g	35	0.7	130	<200	<200
03146	19441	ug/g	6	<0.3	0.1	<20	<20
03151/03152/03153	19453	ug	38.1	<0.6	23	<40	<30
03154	19410	ug	<7	360	2.87	<30	<20
03155		ug	NA	78.9	NA	NA	NA
~~03216/[illegible]~~	~~19455~~	~~ug~~	~~[illegible]~~	77	~~4800~~	~~10000~~	~~<1000~~ *
03217/03218	19454	ug	897	12.9	11600	5360	<200
03219	19411	ug	<7	497	3.80	373	<20
03220		ug	NA	<9	NA	NA	NA
15151/15152/15153	19464	ug	9.5	<0.6	3.06	<30	<30
15154	19412	ug	<8	2	2.3	<40	<30
15155		ug	NA	<8	NA	NA	NA

Comments:
These samples were analyzed on a Jarrell-Ash Model 1155A ICP-AES. a Perkin-Elmer Model 5000 Zeeman atomic absorption spectrometer a Perkin-Elmer Model 3030B atomic absorption spectrometer and a GBC Model 902 atomic absorption spectrometer.
The sample results are as received. in units as listed.

Table 1. Sample Analysis Results.

Project Nos: [illegible] [illegible] Data Analyst: E. McClendon
Lotus File: [illegible] Date: 1-16-90
Analysts: M. Osborn, S. Swaffar, J. Haug, B. Dewalt, E. McClendon
Analysis Dates: 12-14, 16, 18-89, 1-2, 4, 8, 9, 11-90
Analytes: (see below

Sample Analysis Results:
Note: NA = Not Analyzed.
Verified by: ZLM 4-23-90

Sample Number	ASF Bar Code(s)	Sample Units	Element Ag	Element As	Element Ba	Element Be	Element Cd
[illegible]	19449	ug	500✓	1790✓	12100✓	105✓	[illegible]✓
[illegible]	19452	ug	<2000✓	4800✓	18600✓	86✓	[illegible]✓
[illegible]	19455	ug	400✓	[illegible]✓	15100✓	154✓	[illegible]✓

Sample Number	ASF Bar Code(s)	Sample Units	Element Cr	Element Hg	Element Pb	Element Sb	Element Tl
[illegible]	19449	ug	[illegible]✓	[illegible]✓	8500✓	12000✓	[illegible]✓
[illegible]	19452	ug	[illegible]✓	[illegible]✓	[illegible]✓	[illegible]✓	[illegible]✓
[illegible]	19455	ug	[illegible]✓	[illegible]✓	[illegible]✓	[illegible]✓	[illegible]✓

Comments:
These samples were analyzed on a Jarrell-Ash Model [illegible] ICP-AES, a Perkin-Elmer Model 5100 Zeeman atomic absorption spectrometer, a Perkin-Elmer Model [illegible] atomic absorption spectrometer and a [illegible] Model [illegible] atomic absorption spectrometer.
The sample results are as received, in units as listed.

Table 1. Summary of Sample Analysis Results.

Project No.: 9102L5721
Lotus File: 041990B
Analyst: R. Friesen
Analysis Date: 4-19-90
Data Analyst: E. McClendon
Date: 4-24-90
Analyte: (see below)
Sample Matrix: 0.05M H3BO3/10% HNO3

Summary of Sample Analysis Results:

Verified by: Not Approved

Sample Name	ASF Bar Code	Sample Units	Element Ag	Element As	Element Ba	Element Be	Element Cd	Element Cr	Element Pb	Element Sb	Element Tl
32224	01085	ug	300	580	10	<3	2740	338	17800	1700	500

Comments:
The samples were analyzed on a Jarrell-Ash Model 1155A ICP-AES.

Table 21. ICP Drift Determination Data and Calculations.

Project Nos: 9102L5721: 9304L06e1
Lotus File: 121489
Analyst: E. McClendon
Analysis Dates: 1-2, 4, 15-90
Data Analyst: E. McClendon
Date: 1-30-90
Analytes: (see below)
Sample Matrix: 10% HNO3, 10% HNO3/0.05M H3BO3

ICP Drift Determination Data and Calculations:

Verified by EHM 2-7-90

	Element Ag (ug/mL)	Element Ba (ug/mL)	Element Be (ug/mL)	Element Cd (ug/mL)	Element Cr (ug/mL)	Element Pb (ug/mL)	Element Sb (ug/mL)	Element Tl (ug/mL)
1-2-90								
Initial ICS	4.9815	5.0080	2.4647	5.0116	5.0474	4.9866	5.0101	4.9702
ICS1	4.9341	4.9569	2.4363	4.9714	5.0229	4.9449	4.9690	4.8719
% Drift 1	0.95%	1.02%	1.15%	0.80%	0.49%	0.84%	0.82%	1.98%
ICS2	4.9397	4.9847	2.4249	4.9617	5.0243	4.9228	4.9358	4.8630
% Drift 2	0.84%	0.47%	1.61%	1.00%	0.46%	1.28%	1.48%	2.16%
ICS3	4.9742	5.0000	2.4278	4.9613	5.0589	4.8999	4.9236	4.8540
% Drift 3	0.15%	0.16%	1.50%	1.00%	0.23%	1.74%	1.73%	2.34%
ICS4	4.9273	4.9770	2.4226	4.9173	5.0166	4.8038	4.8124	4.7620
% Drift 4	1.09%	0.62%	1.71%	1.88%	0.61%	3.67%	3.95%	4.19%
ICS5	4.8885	4.9196	2.3891	4.8844	4.9611	4.7138	4.7034	4.6960
% Drift 5	1.87%	1.77%	3.07%	2.54%	1.71%	5.47%	6.12%	5.52%
ICS6	4.8943	4.9641	2.3994	4.8766	4.9711	4.6809	4.6886	4.6658
% Drift 6	1.75%	0.88%	2.65%	2.69%	1.51%	6.13%	6.42%	6.12%
ICS7	4.9064	4.9869	2.4069	4.8854	4.9858	4.6913	4.7276	4.6453
% Drift 7	1.51%	0.42%	2.35%	2.52%	1.22%	5.92%	5.64%	6.54%
1-4-90								
Initial ICS	5.0021	4.9843	2.5048	5.0044	5.0875	NA	4.9665	5.1256
ICS1	5.0833	5.0498	2.5334	5.1811	5.2052	NA	5.1295	5.3204
% Drift 1	1.63%	1.31%	1.14%	3.53%	2.31%	NA	3.28%	3.80%
ICS2	5.0834	5.0858	2.5397	5.1769	5.2015	NA	5.3029	5.3821
% Drift 2	1.63%	2.04%	1.39%	3.45%	2.24%	NA	6.77%	5.00%
ICS3	5.0304	5.1159	2.5328	5.1905	5.1852	NA	5.2980	5.4326
% Drift 3	0.57%	2.64%	1.12%	3.72%	1.92%	NA	6.67%	5.99%
ICS4	4.9443	4.9986	2.5097	5.1086	5.1086	NA	5.2367	5.4815
% Drift 4	1.16%	0.29%	0.20%	2.08%	0.41%	NA	5.44%	6.94%

1-15-90								
Initial ICS	4.9262	4.9094	2.5036	4.9690	4.9805	NA	5.1016	5.0089
ICS1	4.9358	4.9446	2.4785	5.0526	5.0437	NA	5.2316	5.0745
% Drift 1	0.19%	0.72%	1.00%	1.68%	1.27%	NA	2.55%	1.31%

Comments:
These samples were analyzed on a Jarrell-Ash Model 1155A ICP-AES.
NA = Not Analyzed.

$$\% \text{Drift} = \frac{|\text{Value} - \text{Initial ICS})}{\text{Initial ICS}} * 100$$

2-7-90

Table 22. Duplicate and Spiked Sample Determinations - Process Samples.

Project Nos: 9102L5721 9304L0661 Data Analyst: E. McClendon
Lotus File: 121489 Date: 1-30-90
Analysts: M. DeBord, S. Swaffar, J. Haug, G. Dewalt, E. McClendon
Analysis Dates: 12-14, 16, 18-89, 1-2, 4, 8, 9, 11-90
Analytes: (see below)

Duplicate and Spiked Sample Determinations - Process Samples:

Verified by: 2-7-90

Sample Number	ASF Bar Code(s)	Sample Units	Element Ag	Element As	Element Ba	Element Be	Element Cd
02127	19416	ug/g	<30	4.96	46.2	<0.2	2
	19417	ug/g	<30	4.82	39.0	<0.2	2
	% Difference		NA	3%	17%	NA	6%
	19418/19419	ug/g	44.8	8.40	73.9	2.94	42.1
	Spike Level	ug/g	35.5	3.30	35.5	3.30	35.5
	% Recovery		126%	106%	88%	89%	114%
02128	19424	ug/g	<20	5.51	160	<0.1	<0.8
	19425	ug/g	<20	5.27	141	<0.1	<0.7
	% Difference		NA	5%	13%	NA	NA
	19426/19427	ug/g	38.2	7.71	267	1.75	3.37
	Spike Level	ug/g	27.7	2.60	27.7	2.60	2.60
	% Recovery		138%	89%	NC	67%	129%
02137	19420	ug/g	<20	4.63	36.7	<0.2	1
	19421	ug/g	<20	5.47	220	<0.2	0.7
	% Difference		NA	17%	143%	NA	53%
	19422/19423	ug/g	44.7	36.9	70.3	2.66	40.7
	Spike Level	ug/g	34.7	34.7	34.7	3.26	34.7
	% Recovery		129%	92%	NC	82%	117%
02145	19432	ug/g	55	9.95	18.2	<0.2	12.3
	19433	ug/g	50	12.8	33.9	0.2	9.75
	% Difference		9%	25%	60%	NA	23%
	19434/19435	ug/g	109	49.6	61.9	4.13	62.1
	Spike Level	ug/g	44.3	44.3	44.3	4.24	44.3
	% Recovery		126%	86%	81%	95%	115%
02146	19436	ug/g	<10	0.07	1.1	<0.06	0.4
	19437	ug/g	<9	0.05	1.0	<0.05	0.4
	% Difference		NA	39%	6%	NA	3%
	19438/19439	ug/g	23.6	1.14	14.8	1.25	1.70
	Spike Level	ug/g	14.2	1.32	14.2	1.32	1.32
	% Recovery		166%	87%	104%	95%	129%

Comments:
These samples were analyzed on a Jarrell-Ash Model 1155A ICP-AES, a Perkin-Elmer Model 5000 Zeeman atomic absorption spectrometer, a Perkin-Elmer Model 3030B atomic absorption spectrometer and a GBC Model 902 atomic absorption spectrometer.
The sample results are as received, in units as listed.
NC = Not Calculated; NA = Not Applicable or Not Analyzed.
Note: Spreadsheet program retains more figures than are displayed.

$\% \text{ Recovery} = \frac{\text{Spike Result} - \text{avg Sx Result}}{\text{Spike Level}} * 100$ or $\% \text{ Recovery} = \frac{\text{Spike Result}}{\text{Spike Level}} * 100$ if Sx Result < DL.

2-7-90

$\% \text{ Difference} = \frac{|\text{Value 1} - \text{Value 2})}{\text{avg Value}} * 100$

F

Table 22. Duplicate and Spiked Sample Determinations - Process Samples (Continued).

Project Nos: 9102L5721 9304L0661 Data Analyst: E. McClendon
Lotus File: 121489 Date: 1-30-90
Analysts: M. DeBord, S. Swaffar, J. Haug, G. Dewalt, E. McClendon
Analysis Dates: 12-14, 16, 18-89, 1-2, 4, 8, 9, 11-90
Analytes: (see below)

Duplicate and Spiked Sample Determinations - Process Samples (Continued):

Verified by: 2-7-90

Sample Number	ASF Bar Code(s)	Sample Units	Element Cr	Element Hg	Element Pb	Element Sb	Element Tl
02127	19416	ug/g	29	<0.8	62.3	<300	<200
	19417	ug/g	22	<0.8	49.2	<200	<200
	% Difference		27%	NA	24%	NA	NA
	19418/19419	ug/g	60.5	36.7	76.2	<200	<200
	Spike Level	ug/g	35.5	35.5	35.5	35.5	35.5
	% Recovery		100%	103%	58%	NC	NC
02128	19424	ug/g	19	0.7	40.1	<300	<200
	19425	ug/g	19	<0.6	42.4	<200	<200
	% Difference		3%	NA	6%	NA	NA
	19426/19427	ug/g	64.6	26.4	77.9	<300	<200
	Spike Level	ug/g	27.7	27.7	27.7	27.7	27.7
	% Recovery		165%	95%	132%	NC	NC
02137	19420	ug/g	22	0.7	46.5	<300	<200
	19421	ug/g	22	<0.6	46.1	<200	<200
	% Difference		0%	NA	1%	NA	NA
	19422/19423	ug/g	69.0	34.8	81.5	<300	<200
	Spike Level	ug/g	34.7	34.7	34.7	34.7	34.7
	% Recovery		135%	100%	102%	NC	NC
02145	19432	ug/g	40	<0.9	210	<300	<200
	19433	ug/g	44	<1	178	<300	<200
	% Difference		10%	NA	16%	NA	NA
	19434/19435	ug/g	85.2	44.4	257	<300	<200
	Spike Level	ug/g	44.3	44.3	44.3	44.3	44.3
	% Recovery		98%	100%	141%	NC	NC
02146	19436	ug/g	5	<0.3	0.2	<20	<20
	19437	ug/g	5	<0.3	<0.2	<20	<20
	% Difference		6%	NA	NA	NA	NA
	19438/19439	ug/g	20.0	13.2	16.1	28.2	<20
	Spike Level	ug/g	14.2	14.2	14.2	14.2	14.2
	% Recovery		105%	93%	113%	198%	NC

Comments:
These samples were analyzed on a Jarrell-Ash Model 1155A ICP-AES, a Perkin-Elmer Model 5000 Zeeman atomic absorption spectrometer, a Perkin-Elmer Model 3030B atomic absorption spectrometer and a SBC Model 902 atomic absorption spectrometer.
The sample results are as received, in units as listed.
NC = Not Calculated; NA = Not Applicable or Not Analyzed.
Note: Spreadsheet program retains more figures than are displayed.

$\% \text{ Recovery} = \frac{\text{Spike Result} - \text{avg Sx Result}}{\text{Spike Level}} \times 100$ or $\% \text{ Recovery} = \frac{\text{Spike Result}}{\text{Spike Level}} \times 100$ if Sx Result < DL.

$\% \text{ Difference} = \frac{|\text{Sx Result 1} - \text{Sx Result 2}|}{\text{avg Sx Result}} \times 100$

2-7-90

Table 23. Duplicate and Spiked Sample Determinations - Train Samples.

Project Nos: 9102L5721 9304L0ea1 Data Analyst: E. McClendon
Lotus File: 121489 Date: 1-30-90
Analysts: M. DeBord. E. Swaffar. J. Haug. G. Dewalt. E. McClendon
Analysis Dates: 12-14. 16. 18-89. 1-2. 4. 8. 9. 11-90
Analytes: (see below)

Duplicate and Spiked Sample Determinations - Train Samples:

Verified by: EEM 2-7-90

Sample Number	ASF Bar Code(s)	Sample Units	Element Ag	Element As	Element Ba	Element Be	Element Cd
02151/02152/02153	19450	ug	<7	0.68	17.2	0.22	4.9
	19450dup	ug	<7	0.66	17.1	0.25	5.0
	% Difference		NA	3%	0%	9%	1%
	19450spk	ug	NA	NA	NA	NA	NA
	Spike Level	ug	NA	NA	NA	NA	NA
	% Recovery		NA	NA	NA	NA	NA
02154	19408	ug	<500	<3	<20	<3	<20
	19408dup	ug	<500	<3	<20	<3	<20
	% Difference		NA	NA	NA	NA	NA
	02154spk	ug	NA	NA	NA	NA	NA
	Spike Level	ug	NA	NA	NA	NA	NA
	% Recovery		NA	NA	NA	NA	NA
02155	02155	ug	NA	NA	NA	NA	NA
	02155dup	ug	NA	NA	NA	NA	NA
	% Difference		NA	NA	NA	NA	NA
	02155spk	ug	NA	NA	NA	NA	NA
	Spike Level	ug	NA	NA	NA	NA	NA
	% Recovery		NA	NA	NA	NA	NA
02216/02222/02223	19452	ug	<2000	5118	19991	92	965
	19452dup	ug	<2000	5151	20052	92	950
	% Difference		NA	1%	0%	0%	1%
	19452spk	ug	NA	NA	NA	NA	NA
	Spike Level	ug	NA	NA	NA	NA	NA
	% Recovery		NA	NA	NA	NA	NA
02217/02218	19451	ug	<60	141	72.6	4.78	454
	19451dup	ug	<60	144	71.9	4.46	448
	% Difference		NA	2%	1%	7%	1%
	19451spk	ug	NA	NA	NA	NA	NA
	Spike Level	ug	NA	NA	NA	NA	NA
	% Recovery		NA	NA	NA	NA	NA
02219	19409	ug	<200	45.2	67.8	<0.9	185
	19409dup	ug	<200	47.1	67.4	<0.9	183
	% Difference		NA	4%	1%	NA	1%
	02219spk	ug	NA	NA	NA	NA	NA
	Spike Level	ug	NA	NA	NA	NA	NA
	% Recovery		NA	NA	NA	NA	NA

02220	02220	ug	NA	NA	NA	NA	NA
	02220dup	ug	NA	NA	NA	NA	NA
	% Difference		NA	NA	NA	NA	NA
	02220spk	ug	NA	NA	NA	NA	NA
	Spike Level	ug	NA	NA	NA	NA	NA
	% Recovery		NA	NA	NA	NA	NA

Comments:

These samples were analyzed on a Jarrell-Ash Model 1155A ICP-AES, a Perkin-Elmer Model 5000 Zeeman atomic absorption spectrometer, a Perkin-Elmer Model 3030B atomic absorption spectrometer and a GBC Model 902 atomic absorption spectrometer.

The sample results are as received, in units as listed.

NC = Not Calculated: NA = Not Applicable or Not Analyzed.

Note: Spreadsheet program retains more figures than are displayed.

$$\%\text{ Recovery} = \frac{\text{Spike Result} - \text{Avg Sx Result}}{\text{Spike Level}} * 100 \text{ or } \%\text{Recovery} = \frac{\text{Spike Result}}{\text{Spike Level}} * 100 \text{ if Sx Result} <.$$

$$\%\text{ Difference} = \frac{|\text{Sx Result 1} - \text{Sx Result 2}|}{\text{Avg Sx Result}} * 100$$

2-7-90

Table II. Duplicate and Spiked Sample Determinations - Train Samples (Continued).

Project Nos: 9102L5721 9304L0661 Data Analyst: E. McClendon
Lotus File: 121489 Date: 1-30-90
Analysts: M. DeBord, S. Swaffar, J. Haug, G. Dewalt, E. McClendon
Analysis Dates: 12-14, 15, 18-89, 1-2, 4, 8, 9, 11-90
Analytes: (see below)

Duplicate and Spiked Sample Determinations - Train Samples (Continued):

Verified by: 2-7-90

Sample Number	ASF Bar Code(s)	Sample Units	Element Cr	Element Hg	Element Pb	Element Sb	Element Tl
02151/02152/02153	19450	ug	97.8	1.9	24	<40	<30
	19450dup	ug	98.5	2.0	23	<40	<30
	% Difference		1%	2%	1%	NA	NA
	19450spk	ug	NA	11.8	NA	NA	NA
	Spike Level	ug	NA	10.5	NA	NA	NA
	% Recovery		NA	94%	NA	NA	NA
02154	19408	ug	<200	497	<6	<700	<500
	19408dup	ug	<200	463	<6	<700	<500
	% Difference		NA	7%	NA	NA	NA
	02154spk	ug	NA	830	NA	NA	NA
	Spike Level	ug	NA	260	NA	NA	NA
	% Recovery		NA	135%	NA	NA	NA
02155	02155	ug	NA	10	NA	NA	NA
	02155dup	ug	NA	10	NA	NA	NA
	% Difference		NA	1%	NA	NA	NA
	02155spk	ug	NA	37.8	NA	NA	NA
	Spike Level	ug	NA	28.0	NA	NA	NA
	% Recovery		NA	100%	NA	NA	NA
02216/02222/02223	19452	ug	10008	173	8162	6820	<4000
	19452dup	ug	10007	176	8336	7105	<4000
	% Difference		0%	2%	2%	4%	NA
	19452spk	ug	NA	528	NA	NA	NA
	Spike Level	ug	NA	370	NA	NA	NA
	% Recovery		NA	96%	NA	NA	NA
02217/02218	19451	ug	4664	7.97	2880	666	<300
	19451dup	ug	4595	7.82	3171	653	<300
	% Difference		2%	2%	10%	2%	NA
	19451spk	ug	NA	17.7	NA	NA	NA
	Spike Level	ug	NA	9.73	NA	NA	NA
	% Recovery		NA	101%	NA	NA	NA
02219	19409	ug	3665	392	800	369	<200
	19409dup	ug	3654	407	787	364	<200
	% Difference		0%	4%	2%	2%	NA
	02219spk	ug	NA	655	NA	NA	NA
	Spike Level	ug	NA	279	NA	NA	NA
	% Recovery		NA	91%	NA	NA	NA

02220	02220	ug	NA	<9	NA	NA	NA
	02220dup	ug	NA	<10	NA	NA	NA
	% Difference		NA	NA	NA	NA	NA
	02220spk	ug	NA	66.6	NA	NA	NA
	Spike Level	ug	NA	66.4	NA	NA	NA
	% Recovery		NA	100%	NA	NA	NA

Comments:

These samples were analyzed on a Jarrell-Ash Model 1155A ICP-AES, a Perkin-Elmer Model 5000 Zeeman atomic absorption spectrometer, a Perkin-Elmer Model 3030B atomic absorption spectrometer and a GBC Model 902 atomic absorption spectrometer.

The sample results are as received, in units as listed.

NC = Not Calculated: NA = Not Applicable or Not Analyzed.

Note: Spreadsheet program retains more figures than are displayed.

$$\%\ \text{Recovery} = \frac{(\text{Spike } \overset{\text{Result 2-7-90}}{\cancel{\text{Level}}} - \text{Avg Sx Result})}{\text{Spike Level}} * 100 \quad \text{or} \quad \%\ \text{Recovery} = \frac{(\text{Spike Result})}{\text{Spike Level}} * 100$$

if Sx Result <DL

$$\%\ \text{Difference} = \frac{|\text{Sx Result 1} - \text{Sx Result 2}|}{\text{avg Sx Result}} * 100$$

2-7-90

Table 24. Duplicate and Spiked Sample Determinations - NBS and House Samples.

Project Nos: 910L5721 9304L0601 Data Analyst: E. McClendon
Lotus File: 121489 Date: 1-30-90
Analysts: M. DeBord, S. Swaffar, J. Haug, G. Dewalt, E. McClendon
Analysis Dates: 12-14, 16, 18-89, 1-2, 4, 8, 9, 11-90
Analytes: (see below)

Duplicate and Spiked Sample Determinations - NBS and House Samples:
Note: NA = Not Analyzed.
Verified by: 2-7-90

Sample	ASF Bar Code(s)	Sample units	Element Ag	Element As	Element Ba	Element Be	Element Cd
NBS 2676c Ic	19456	ug	<6	NA	<0.4	<0.03	1.18
	Cert. Val.	ug	NC	NC	NC	NC	0.954
	% Recovery		NA	NA	NA	NA	124%
NBS 2676c IIc	19457	ug	<6	NA	<0.4	<0.04	3.10
	Cert. Val.	ug	NC	NC	NC	NC	2.83
	% Recovery		NA	NA	NA	NA	109%
NBS 2676c IIIc	19458	ug	<6	NA	<0.4	<0.03	10.97
	Cert. Val.	ug	NC	NC	NC	NC	10.09
	% Recovery		NA	NA	NA	NA	109%
NBS 2676c Blank	19459	ug	<6	NA	<0.4	<0.04	<0.7
	Cert. Val.	ug	NC	NC	NC	NC	<0.01
NBS 2677 I	19460	ug	<6	0.252	<0.3	0.047	<0.6
	Cert. Val.	ug	NC	0.103	NC	0.052	NC
	% Recovery		NA	244%	NA	91%	NA
NBS 2677 II	19461	ug	<6	1.45	<0.4	0.274	<0.7
	Cert. Val.	ug	NC	1.07	NC	0.256	NC
	% Recovery		NA	136%	NA	107%	NA
NBS 2677 III	19462	ug	<6	12.5	<0.4	1.11	<0.7
	Cert. Val.	ug	NC	10.5	NC	1.03	NC
	% Recovery		NA	119%	NA	108%	NA
NBS 2677 Blank	19463	ug	<6	<0.1	<0.4	<0.04	<0.7
	Cert. Val.	ug	NC	<0.002	NC	<0.001	NC
House Front Half							
Blank	19443	ug	<7	0.31	4.77	<0.04	<0.8
Lo Spk	19444	ug	<6	2.58	7.20	2.40	2.44
	Spike	ug	2.50	2.50	2.50	2.50	2.50
	% Recovery		NA	91%	97%	96%	97%
Hi Spk	19445	ug	<7	33.2	29.7	22.9	22.9
	Spike	ug	25.0	25.0	25.0	25.0	25.0
	% Recovery		NC	131%	100%	92%	92%
House Back Half							
Blank	19402	ug	<20	<0.09	<0.6	<0.09	<0.7
Lo Spk	19403	ug	<20	2.37	2.73	2.22	2.23
	Spike	ug	2.50	2.50	2.50	2.50	2.50
	% Recovery		NA	95%	109%	89%	89%
Hi Spk	19404	ug	<20	24.6	24.4	23.9	24.2
	Spike	ug	25.0	25.0	25.0	25.0	25.0
	% Recovery		NC	98%	97%	95%	97%

Comments:

These samples were analyzed on a Jarrell-Ash Model 1155A ICP-AES, a Perkin-Elmer Model 5000 Zeeman atomic absorption spectrometer, a Perkin-Elmer Model 3030B atomic absorption spectrometer and a GBC Model 902 atomic absorption spectrometer.

The sample results are as received, in units as listed.

NC = Not Calculated; NA = Not Applicable or Not Analyzed.

Note: Spreadsheet program retains more figures than are displayed.

$$\% \text{ Recovery} = \frac{\text{Value}}{\text{Certified Value}} \times 100$$

or

$$\% \text{ Recovery} = \frac{\text{Value}}{\text{Spike}} \times 100 \quad \text{or} \quad \% \text{ Recovery} = \frac{\text{Value} - \text{Blank}}{\text{Spike}} \times 100$$

2-7-90

Table 24. Duplicate and Spiked Sample Determinations - NBS and House Samples (Continued).

Project Nos: 9102L5721, 9304L0661
Lotus File: 101489
Data Analyst: E. McClendon
Date: 1-30-90
Analysts: M. DeBord, B. Swaffer, J. Haug, G. Dewalt, E. McClendon
Analysis Dates: 12-14, 15, 18-89, 1-2, 4, 8, 9, 11-90
Analytes: (see below)

Duplicate and Spiked Sample Determinations - NBS and House Samples (Continued):
Note: NA = Not Analyzed.
Verified by: glm 2-7-90

Sample	ASF Bar Code(s)	Sample Units	Element Cr	Element Hg	Element Pb	Element Sb	Element Tl
NBS 2676c Ic	19456	ug	<3	NA	7.52	<30	<30
	Cert. Val.	ug	NC	NC	7.47	NC	NC
	% Recovery		NA	NA	101%	NA	NA
NBS 2676c IIc	19457	ug	3	NA	16.28	<30	<30
	Cert. Val.	ug	NC	NC	14.92	NC	NC
	% Recovery		NA	NA	109%	NA	NA
NBS 2676c IIIc	19458	ug	3	NA	32.55	<30	<30
	Cert. Val.	ug	NC	NC	29.81	NC	NC
	% Recovery		NA	NA	109%	NA	NA
NBS 2676c Blank	19459	ug	<3	NA	<0.3	<30	<30
	Cert. Val.	ug	NC	NC	<0.01	NC	NC
NBS 2677 I	19460	ug	<3	NA	NA	<30	<30
	Cert. Val.	ug	NC	NC	NC	NC	NC
	% Recovery		NA	NA	NA	NA	NA
NBS 2677 II	19461	ug	<3	NA	NA	<30	<30
	Cert. Val.	ug	NC	NC	NC	NC	NC
	% Recovery		NA	NA	NA	NA	NA
NBS 2677 III	19462	ug	<3	NA	NA	<30	<30
	Cert. Val.	ug	NC	NC	NC	NC	NC
	% Recovery		NA	NA	NA	NA	NA
NBS 2677 Blank	19463	ug	<3	NA	NA	<30	<30
	Cert. Val.	ug	NC	NC	NC	NC	NC
House Front Half							
Blank	19443	ug	6	<0.6	2.29	<40	<30
Lo Spk	19444	ug	11	NA	5.44	<30	<30
	Spike	ug	2.50	2.50	2.50	2.50	2.50
	% Recovery		192%	NA	126%	NA	NA
Hi Spk	19445	ug	32.8	16.7	36.4	<40	<30
	Spike	ug	25.0	25.0	25.0	25.0	25.0
	% Recovery		106%	66.7%	136%	NC	NC
House Back Half							
Blank	19402	ug	<6	<2	1.00	<30	<30
Lo Spk	19403	ug	<6	<2	3.94	<30	<20
	Spike	ug	2.50	2.50	2.50	2.50	2.50
	% Recovery		NA	NA	118%	NA	NA
Hi Spk	19404	ug	26.2	18.7	28.2	<30	21.7
	Spike	ug	25.0	25.0	25.0	25.0	25.0
	% Recovery		105%	75%	109%	NA	87%

Comments:

These samples were analyzed on a Jarrell-Ash Model 1155A ICP-AES, a Perkin-Elmer Model 5000 Zeeman atomic absorption spectrometer
a Perkin-Elmer Model 3030B atomic absorption spectrometer and a GBC Model 902 atomic absorption spectrometer.

The sample results are as received, in units as listed.

NC = Not Calculated; NA = Not Applicable or Not Analyzed.

Note: Spreadsheet program retains more figures than are displayed.

$$\% \text{ Recovery} = \frac{\text{Value}}{\text{Certified Value}} * 100$$

or

$$\% \text{ Recovery} = \frac{\text{Value}}{\text{Spike}} * 100 \text{ or} \qquad \% \text{ Recovery} = \frac{\text{Value} - \text{Blank}}{\text{Spike}} * 100$$

EHM 2-7-90

Table 25. Serial Dilution Results.

Project Nos: 9102L5701; 9304L0661　　　Data Analyst: E. McClendon
Lotus File: 121489　　　Date: 1-30-90
Analysts: M. DeBord, S. Swaffar, J. Haug, G. Dewalt, E. McClendon
Analysis Dates: 12-14, 15, 18-89, 1-2, 4, 8, 9, 11-90
Analytes: (see below)

Serial Dilution Results:

Verified by: Edm 2-7-90

Sample	ASF Bar Code(s)	Sample Units	Element Ag	Element As	Element Ba	Element Be	Element Cd	Element Cr	Element Pb	Element Sb	Element Tl
02151/02152/02153	19450	ug	<7	0.67	17.1	0.24	5.0	98.1	23	<40	<30
		ug	<20	0.83	18.8	0.29	5.6	114	24	<70	<60
	% Difference		NA	25%	10%	23%	14%	16%	2%	NA	NA
02154	19408	ug	<500	<3	<20	<3	<20	<200	<6	<700	<500
		ug	<800	<5	<30	<5	<40	<300	<20	<2000	<1000
	% Difference		NA	NA	NA	NA	NA	NA	NA	NA	NA
02216/02222/02223	19452	ug	<2000	NA	20021	92	957	10007	8249	6962	<4000
		ug	<3000	NA	20319	93	980	10170	8831	8021	<8000
	% Difference		NA	NA	1%	1%	2%	2%	7%	15%	NA
02217/02218	19451	ug	<60	142	72.3	4.62	451	4630	3025	659	<300
		ug	<200	149	73.2	4.76	465	4756	3138	684	<500
	% Difference		NA	5%	1%	3%	3%	3%	4%	4%	NA
02219	19409	ug	<200	46.2	67.6	<0.9	184	3659	794	367	<200
		ug	<400	54.9	69.6	<2	187	3741	795	<600	<400
	% Difference		NA	19%	3%	NA	2%	2%	0%	NA	NA

Comments:
These samples were analyzed on a Jarrell-Ash Model 1155A ICP-AES, a Perkin-Elmer Model 5000 Zeeman atomic absorption spectrometer, a Perkin-Elmer Model 3030B atomic absorption spectrometer and a GBC Model 902 atomic absorption spectrometer.
The sample results are as received, in units as listed.
NC = Not Calculated; NA = Not Applicable or Not Analyzed.
Note: Spreadsheet program retains more figures than are displayed.

$$\%\text{Difference} = \frac{|\text{Serial Dilution Result} - \text{Avg Sx Result}|}{\text{Avg Sx Result}} * 100$$

APPENDIX G

MODIFICATIONS TO EPA DRAFT METALS PROTOCOL AND EPA SW-846

Modifications to EPA Draft Metals Protocol

The EPA draft method for sampling and analysis of metals in the stack emissions will be utilized for this project, with the following modifcations or clarifications:

1. Metals to be analyzed in the samples will be limited to the following 10 metals, since these are the only metals included in the draft EPA regulations: As, Cd, Cr, Be, Sb, Ba, Pb, Hg, Ag and Tl.

2. Two condensate impingers will be used, instead of the single optional condensate impinger. This is necessary due to the large volume of condensate expected.

3. Reagent blanks will be taken but not analyzed unless necessary. Analysis of reagent blanks should not be necessary, since a complete blank train wil be assembled, and the samples recovered for analysis.

4. ASTM Type I water will be used in place of the ASTM Type II water specified. Type I water is defined by ASTM to have a resistance of 17 megohm/cm, which is a measure of the total metals content of the water. Type I water easily should meet the 1 ng/mL requirement by its nature, without requiring further analysis.

5. The acid probe wash and acetone probe was residue will be combined and reduced in volume and then combined with the enitre filter prior to digestion (in a microwave digesiton bomb) in order to minimize the final digestate volume. This procedure has been used in other trial burns with no detrimental effects upon the sample preparation or analysis and has the advantage of better detection limits. If a cyclone catch is present, its state of homogeniety will be assessed. If the sample is adequately homogenous, a portion of the catch will be separately digested in a micrwave digestion bomb in order to minimize the volume of sample resulting for the front half of the train.

6. The analysis procedures contained in the method are basically a compendium of the SW-846 methods and quality control procedures for metals. Analysis on this project will follow the SW-846 method with some modifications.

Method Modifications for EPA SW-846 (third edition)

Note: The following modifications are listed by Method number and applicable paragraph. Paragraphs which are not listed are not changed.

Method 3050

Paragraph 1.1 (addition) This method may also be employed for the more rigorous digestion of liquids, with appropriate changes in sample size. This method may be used for the GFAA analysis of lead.

Paragraph 2.1 (addition) ICP may also be performed on the digests prepared as for GFAA in this method.

Paragraph 7.1 Mix the sample thoroughly to achieve homogeneity. For each digestion procedure, weigh to the nearest 0.01 g and transfer to a conical or straight sided beaker an appropriate amount of sample. For solids, transfer between 0.50- to 1.00-g for each 50-g final digestate and for liquids, 50-g for each 50-g final digestate. (Note: the digestion instructions which follow are for the digestion of 0.5-g solid and 50-g liquid samples. If sample sizes are to be larger, increment the reagents and final weights accordingly.)

Paragraph 7.2 Add 5 mL of 1:1 HNO3, mix the sample, and cover with a watch glass. Heat the liquid samples gently (without boiling) on a hot plate until their volume is reduced to approximately 10 mL. If ribbed watch glasses are not available, remove the watch glasses to accelerate volume reduction while assuring minimal contamination of the samples. After the volume has been reduced, replace the watch glass and proceed with the digestion of all samples. Heat the sample to 95 C and reflux for 10 to 15 minutes without boiling. Allow the sample to cool, add 2.5 mL of concentrated HNO3, replace the watch glass, and reflux for 30 minutes. Repeat this last step to ensure complete oxidation. Allow the solution to evaporate to 5 mL without boiling while maintaining a covering of solution over the bottom of the beaker. It may be necessary to conduct this volume reduction without the watch glasses while assuring minimal contamination of the samples if ribbed watch glasses are not available.

Paragraph 7.5 (comment) This paragraph will not be used to complete the digestion of these samples for ICP as samples digested under this portion of the method could not be subsequently be reanalyzed by GFAA due to their HCl content. Instead, the digestion will be completed employing paragraph 7.6.

Paragraph 7.6 If the sample is being prepared for ICP analysis or the furnance analysis of As, Be, Cd, Cr, Co, Pb, Mo, Se, Tl, and V, continue heating the acid-peroxide digestate carefully without watch glasses unitl the volume has been reduced to approximately 5 mL. After cooling, dilute to 50-g with Type II water. Particluates in the digestate should then be removed by filtrateion, by centrifugation, or by allowing the sample to settle.

Method 6010

Paragraph 5.4 Mixed Calibration Standard Solutions: MRI will use commercially available multielement standards, since use and preparation of individually prepared standards is not cost effective. These standard solutions will be prepared in 10 percent nitric acid or matrix matched to the samples.

Paragraph 5.5.1 The calibration blank will be prepared so as to contain 10 percent nitric acid or other acid to match the calibration standards in paragraph 5.4.

Paragraph 5.7 The interference check solution is prepared to contain known concentrations of interfering elements that will provide an adequate test of the correction factors. Spike the sample with the elements of interest at a 1 mcg/mL level. In the absence of measurable analyte, overcorrection could go undetected because a negative value could be reported as zero. If the particular instrument will display overcorrection as a negative number, this spiking procedure will not be necessary.

Paragraph 5.8 The quality control sample(s) should be prepared in the same acid matix as the calibration standards at a 1 mcg/mL level from standards from an alternate lot than the calibration standards.

Paragraph 8.6.2.1 (addition) The expected value is defined to be the concentration obtained for the check standard analyzed subsequent to the calibration of the instrument.

Method 7060

Paragraph 2.1 Prior to analysis by Method 7060, samples must be prepared in order to convert organic forms of arsenic to inorganic forms, to minimize organic interferences, and to convert the sample to a siutable solution for analysis. Method 3050 may be employed for the preparation of aqueous or sludge samples. Aqueous samples may alternately be subjected to the acid digestion procedure described in this method.

Paragraph 2.2 Nickel nitrate (1000 mcg/mL, an experimentally predetermined volume) is added as a co-analyte by the GFAA autosampler to the graphite tube after sample addition but prior to the drying step.

Paragraph 3.2 Likewise, caution must be employed during the selection of temperature and times for the dry and char (ash) cycles. A nickel nitrate solution is added to the sample in the graphite tube furnace prior to the drying step to minimize volatilization losses during drying and ashing.

Paragraph 3.4 A clean-out step is programmed into the furnance to clean the tube after each analysis to assure complete volatilization of the analyte from the graphite tube furnace.

Paragraph 4.3 Atomic absorption spectrophotometer: A Perkin Elmer Zeeman 5000 (PE-5000) atomic absorption unit will be employed. Data output will be to a Perkin Elmer DS-10 Data Station. The PE-5000 cannot output data to a strip chart recorder and the Data Station simultaneously. Data from the Data Station will be used for calculations.

Paragraph 4.6 A Perkin Elmer DS-10 Data Station will be employed in the collection of data as described in paragraph 4.3.

Paragraph 5.4 Arsenic standard stock solution: Procure a certified aqueous standard from a supplier and verify by comparison with a second standard from a different lot, from the same or an alternate manufacturer.

Paragraph 5.5 Nickel nitrate solution (5%): A commercially prepared GFAA nickel nitrate (1000 mcg/mL) will be employed.

Paragraph 5.6 (comment) The nickel nitrate solution as described in paragraph 5.5 will be employed without dilution.

Paragraph 5.7 Arsenic working standards: Working standards will be prepared such that the final acid concentration corresponds as closely as possible to that of the samples.

Paragraph 7.1 Aqueous and sludge-type samples can be prepared according to Method 3050. Aqueous samples can also be prepared in the manner describe in Paragraphs 7.1.1-7.1.3. The applicability of a sample- preparation technique to a new matrix must be demonstrated by analyzing spiked samples and/or relevenat standard reference materials.

Paragraph 7.6 Midpoint standards will be anlayzed at a frequency of 1 for every 10 samples. If the value obtained varies more than 20% from the corresponding standard in the calibration curve, the instrument will be recalibrated and all samples subsequent to an acceptible midpoint standard will be reanalyzed.

Paragraph 8.2 Calibration curves must be composed of a minimum of a blank and three standards. A midpoint check standard will be analyzed as per paragraph 7.6.

Paragraph 8.5 A midpoint check standard will be analyzed to verify calibration as per paragraph 7.6.

Method 7421

Paragraph 4.1 Atomic absorption spectrophotometer: A Perkin Elmer Zeeman 5000 (PE-5000) atomic absorption unit will be employed. Data output will be to a Perkin Elmer DS-10 Data Station. The PE-5000 cannot output data to a strip chart recorder and the Data Station simultaneously. Data from the Data Station will be used for calculations.

Paragraph 5.2 Procure a certified aqueous standard from a supplier and verify by comparison with a second standard from a different lot, from the same or an alternate manufacturer.

Paragraph 5.3 Working standards will be prepared as calibration standards and will be prepared with a final acid concentration which corresponds as closely as possible to that of the samples.

Paragraph 7.2 (addition) A midpoint standard will be analyzed as an instrument check standard to verify calibration after each 10 analyses.

Method 7470

Paragraph 1.1 (addition) This method may be used for the analysis of mercury in Method 3050 digestates.

Paragraph 4.1 Atomic Absorption Spectrometer. A Perkin-Elmer Model 3030B or GBC Model 902 equipped with a closed loop mercury vapor generation apparatus will be used.

Paragraph 4.3 This piece of apparatus is not used with the Perkin-Elmer Model 3030B or GBC Model 902 as the absorbance is displayed.

Paragraph 4.4 (comment) The apparatus used is similar to that described in this paragraph except that the 2-in. x 2-in. cards are not used.

Paragraphs 4.6 and 4.8. These pieces of apparatus are not used with the systems currently in use on the Perkin-Elmer Model 3030B and GBC Model 902.

Paragraph 5.5 Stannous Sulfate. Add 25 g stannous sulfate (or stannous chloride) to 125 mL concentrated hydrochloric acid. Allow to dissolve then carefully dilute to 250 mL with Type II water.

Paragraph 5.9 Stock Mercury Solution. Procure a certified aqueous standard from a supplier. Prepare a 1 ug/mL working solution in 10% nitric acid from this standard for the preparation of the standards for the calibration curve.

Paragraph 7.1 Sample Preparation. Transfer 5 to 10 g of sample to a 250-mL glass stoppered Erlenmeyer flask. Add 5 mL concentrated H2SO4 and 2.5 mL concentrated HNO3, mixing after each addition. Add 10 mL of potassium permanganate solution and mix. Add additional portions of potassium permanganate solution, if necessary, until the purple color remains in all samples for at least 15 minutes. Add 4 mL potassium persulfate solution to each sample and heat for 2 hr in a water bath maintained at 95 degrees C cool and add 3 mL of sodium chloride- hydroxylamine sulfate to reduce the excess permanganate. Transfer to labelled 100 mL volumetric flasks and dilute to the mark with Type II water. Continue as described in Paragraph 7.3.

Paragraph 7.2 Standard Preparation. Transfer appropriate amounts of the 1 ug/mL working solution prepared in Paragraph 5.9 into 250 mL glass stoppered Erlenmeyer flasks for the calibration curve. Add enough Type II water to make a total volume approximately that of the samples. Mix thoroughly and add 5 mL concentrated H2SO4 and 2.5 mL concentrated HNO3, mixing after each addition. Add 10 mL of potassium permanganate solution and mix. Add additional portions of potassium permanganate solution, if necessary, until the purple color remains in all samples for at least 15 minutes. Add 4 mL potassium persulfate solution to each sample and heat for 2 hr in a water bath maintained at 95 degrees C. cool and add 3 mL of sodium chloride-hydroxylamine sulfate to reduce the excess permanganate. Transfer to labelled 100 mL volumetric flasks and dilute to the mark with Type II water. Continue as described in Paragraph 7.3.

Paragraph 7.3. Analysis. Pipet an appropriate amount of sample, standard or blank into the reaction cell. Attach the cell to the system. Add a predetermined amount of stannous sulfate/chloride solution (prepared in Paragraph 5.5) to the sample and start the recirculating pump. When the absorbance reading levels off (approximately 30-45 seconds), record the value. Then open the valves and vent the system until it returns to a minimum value. Remove the reaction cell, rinse the system where the reaction cell attaches and close the valves. The system is ready for the next analysis.

Paragraph 8.2 Calibraton curves must be composed of a minimum of a blank and three standards. Instrument drift should be monitored by analyzing a standard at approximately the midpoint of the calibration curve after every 10 analyses.

APPENDIX H

FIELD DATA SHEETS

MIDWEST RESEARCH INSTITUTE

Run Number 01 Project Number 9102-57-20

Date 11-~~17~~ -16- -89

Plant TWI #4 Sauget, Illinois

Sampling Location Inlet to the S.D.A.

FIELD CREW

Crew Chief	Dick Carb
Testing Engineer	Frank Grammer
Assistant Testing Engineer	Dan March
Process Engineer	Paul Gorman
Other	

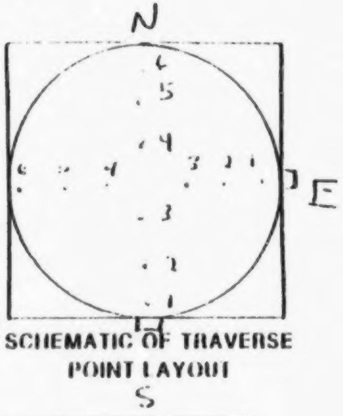
JB
12/2/89

FIELD DATA

RUN NO 01
PROJECT NO 9102-57-20
PLANT TWI #4 Sauget, Illinois
DATE ~~11-16/17/89~~ 11-16,17-89
SAMPLING LOCATION inlet to S.D.A.
SAMPLE TYPE MM5 - Metals
OPERATOR Ron K. Grammer
FILTER NO 144
RECORD DATA EVERY 5 MIN
UMBILICAL/SAMPLE BOX NO 1111-6

PROBE NO W.C.-2-10
PROBE LENGTH AND TYPE 10', reflex, M5
SAMPLE BOX NO 11190
METER BOX NO 10
TEMP CONTROLLER NO Y-0768
TEMP METER NO 7517
THERMOCOUPLE ID NO T.C.-W.C.-2-10
UMBILICAL CORD ID NO U-25-2
UMBILICAL CORD ID NO H.L.-2
NOZZLE NO W-#1 1/4

NOZZLE DIA .317
ASSUMED MOISTURE % 32
METER ΔH@ 1.78
METER CORRECTION .99
PITOT NO W.C.-2-10
PITOT COEFFICIENT .84
BAROMETRIC PRESSURE 29.23
SITE TO BARO ELEVATION (ft) 60
CORRECTED B.P. (0.1 in/100 ft) 29.17 29.50 11-17-89
STATIC PRESSURE -1.5



SCHEMATIC OF TRAVERSE POINT LAYOUT

PITOT LEAK CHECK ≥ 3" H_2O

	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)	0950	1735	1040	1223	1315	1440
PASS/FAIL		PASS		PASS		PASS

PITOT LEAK CHECK ≥ 3" H_2O

	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)						
PASS/FAIL						

SAMPLE TRAIN LEAK CHECKS

	INITIAL	FINAL	INITIAL	FINAL	INITIAL
TIME (24 hr)	0945	1740	1035	1227	1330
VACUUM, in. Hg	≥15"	5"	≥15"	9"	≥15"
CFM	.004	.003	.003	.003	.004
VOLUMES		DM			
FINAL			47.847	3.887	66.888
INITIAL			43.460	2.612	64.276
DIFFERENCE			3.887	6.499	2.612

SAMPLE TRAIN LEAK CHECKS

	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)	1435				
VACUUM, in. Hg	7.1"	≥15"		≥15"	
CFM	.006				
VOLUMES					
FINAL					
INITIAL					
DIFFERENCE					

INITIAL VOLUME 17.091 11.651
FINAL VOLUME 108.364
LEAK CHECK VOLUME 6.499
ADJUSTED FINAL VOLUME 101.865

COMMENTS

RB 12/21/89

Revision 11/18/86

RUN NO. 01
DATE 11-16,17-89
47.847
SAMPLING LOCATION inlet to the S.D.A.
PROJECT NO. 9102-57-20
P. 1 of 1
OPERATOR Frank Grummer

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24-hr)	GAS METER READING (V$_m$), ft^3 DESIRED	INITIAL ~~17.841~~ .631 FG ACTUAL	VELOCITY HEAD (Δp$_s$), in. H$_2$O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H$_2$O DESIRED	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H$_2$O ACTUAL	STACK TEMP. (T$_s$), °F	DRY GAS METER TEMPERATURE INLET (T$_{m\,in}$), °F	DRY GAS METER TEMPERATURE OUTLET (T$_{m\,out}$), °F	PUMP VAC., in. Hg	IMPINGER TEMP., °F	SAMPLE BOX TEMP., °F	PROBE TEMP., °F	FILTER TEMP., °F	heated line	water exit [illegible]	O2 meter
	0	1656																
S-6	5	1701	21.44	21.4	.90	1.96	2.0	822	32	31	0	33	256	221	262	NA	NA	6.8
6	10	1706	24.93	24.30	.77	1.28	1.7	805	45	38	0	29	221	231	270			7.8
5	15	1711	29.07	27.50	1.0	2.23	2.7	824	48	39	0	38	235	230	256			5.8
5	20	1716	33.37	31.62	1.1	2.47	2.7	829	50	40	2.5	39	235	221	254			6.2
4	25	1721	37.67	36.40	1.1	2.46	2.7	835	52	41	2.8	37	233	246	253			7.3
4	30	1726	41.62	40.10	.93	2.67	2.7	841	53	41	2.8	39	234	244	248			5.7
3	35	1731	45.57	43.96	.93	2.04	1.7	854	55	42	3.0	38	233	234	248			6.0
3	40	1157	51.33	51.34	.74	1.62	1.6	850	43	42	1.0	29	232	172	228			10.5
2	45	1202	54.78	54.30	.7	1.57	1.57	844	52	45	1.8	43	236	190	239			7.3
2	50	1207	58.17	57.40	.67	1.51	1.57	842	56	49	2.0	45	235	194	238			6.9
1	55	1212	61.66	61.04	.70	1.60	1.80	829	58	50	2.7	47	240	199	237			7.5
1	60	1217	64.767	64.276	.55	1.26	1.60	825	60	51	2.2	47	257	202	251			6.9
	0	1330		66.888														
E-6	5	1335	70.40	70.02	.72	1.63	1.70	835	52	51	2.0	45	264	197	280			5.5
6	10	1340	74.24	73.93	.84	1.97	2.2	830	54	53	3.2	47	239	247	272			5.7
5	15	1345	77.84	77.42	.74	1.69	2.0	841	63	54	3.2	45	239	212	269			5.3
5	20	1350	81.88	81.24	.90	2.07	2.5	835	64	55	4.8	45	231	261	266			4.4
4	25	1355	85.29	85.11	.65	1.50	2.0	828	66	56	4.3	45	242	232	269			4.4
4	30	1400	89.34	88.98	.92	2.12	2.5	839	67	57	5.7	44	239	243	259			4.4
3	35	1405	93.43	93.04	.93	2.15	2.8	839	70	58	7.0	45	236	243	264			4.9
3	40	1410	97.15	97.15	.77	1.77	2.3	846	71	59	6.1	46	237	236	259			4.4
2	45	1415	100.59	100.86	.66	1.51	2.0	844	71	60	5.8	47	235	233	258			4.6
2	50	1420	103.53	104.07	.48	1.10	1.5	842	70	60	4.7	47	237	239	262			4.8
1	55	1425	105.97	106.52	.33	.76	.7	833	69	60	2.4	44	238	242	259			4.8
1	60	1430	108.045	108.369	.24	.55	.4	836	66	60	1.0	42	235	229	259			4.3

COMMENTS

JB
12-12-89

Revision 9 4 86

INTEGRATED GAS SAMPLING DATA FORM
FOR U.S. EPA METHOD 3

Plant TWI #4, Sauget, Illinois
Run No. 01
Date 11-17-89
Sampling Location inlet to the SDA
Operator Frank Grammer
Sample Type (Multi-Point, Single-Point) Multi-Point
Bag Type Mylar
Sample No. 1229
For Sampling From M5 Console No. 12
Method 3 Train No. NA
Pump Type diaphragm
Pump Type NA
Pump I.D. NA
Pump I.D. NA
Flow Meter Type Dwyer 0-500 cc/min air
Flow Meter Type NA
Flow Meter I.D. NA
Flow Meter I.D. NA
Flow Control Device (Microvalve, Critical Orifice) Microvalve and Critical orifice
Desired Flow Rate (cc/min) 400
Leak Check Before Sampling OK
After Sampling OK
75 Total Sampling Time (min) ~~[illegible]~~ min
Average Flow Meter Reading 350
Flow Rate (cc/min): Average 350
Highest 350
Lowest 350
Estimated Actual Volume (liters) 26.25

Time 24 Hr Clock	Flow Meter Reading	Comments
1706	350	started sampling 11-16-89
1731	350	Stopped sampling - NA - 25 minutes - NA
1200	350	started Sampling
1317	350	Stopped Sampling 17 minutes
1332	350	started Sampling
1430	350	stopped sampling 58 ~~[illegible]~~ minutes
		ORSAT SAMPLE FROM 11-16-89 was
		evacuated FROM the mylar bag due to
		NOT completing the run and being unable
		to analyze the sample within four hours

PJ 12/7/89

15

Run No. 1
Project No. 9304L-06-32
Date 11 / 17 /89
Plant TWI Div. of CWM
Recovery Person T. Hartman

METALS - SDA INLET

SAMPLE BOX NO. 011190

FILTER NO. 144 ____ Color/condition Light Brown/Heavy loading
_1218

IMP. 1	IMP. 2	IMP.3	IMP. 4	IMP. 5	IMP. 6
MGBS/2L ~~Dry~~ 300 ml H_2O	MGBS HNO3/H2O2 100 ml	GBS HNO3/H2O2 100 ml	MGBS KMnO4 100 ml	Mod KMnO4 100 mL	Mod Silica

	FINAL	INITIAL	DIFFERENCE
IMP. 1	2345.1 g	1573.8 g	771.3 g
IMP. 2	869.2	618.8	249.4
IMP. 3	733.9	617.0	116.9
IMP. 4	724.2	627.0	97.2
IMP. 5	517.9	549.8	-31.9
IMP. 6	652.3	666.4	[illegible].4

% Blue 15

TOTAL [1169.2]

SAMPLE BOTTLES

	Condensate HNO3/H2O2 _1219	KMnO4 _1220	PROBE RINSE ACETONE _1216 1222 FH	PROBE RINSE HNO3 _1217	Dry Catch 1223
FINAL	3036.2 g	655.7	615.4	~~474.5~~ TH 518.3	
INITIAL	1238.6 g	256.9	255.3	256.1	
DIFFERENCE	[1797.6]	[398.8]	[360.1]	[262.2]	
LEVEL MARKED	____	____	____	____	

COMMENTS: 1222 FH Acetone Initial wt 256.4 Final wt 421.9
1221 – 15ml of aliquot taken out of #1 Impinger
Appears as though liquid pulled backwards through train, Filter OK
1223 - Dry catch

VOLUMES

MOISTURE VOLUME	1169.2	PROBE RINSE ACETONE	360.1
CONDENSATE/HNO3/H2O2	1797.6	PROBE RINSE HNO3	262.2
KMnO4	398.8		

Reviewed by ____ PB Date 11/19/89

MIDWEST RESEARCH INSTITUTE

Run Number 02
-20-
-19-

Project Number 9102-57-20

Date 11-18-89

Plant TWI #4, Sauget, Illinois

Sampling Location inlet to the spray dryer absorber

FIELD CREW

Crew Chief	Dick Cobb
Testing Engineer	Frank Grammer
Assistant Testing Engineer	Dan March
Process Engineer	Paul Gorman
Other	

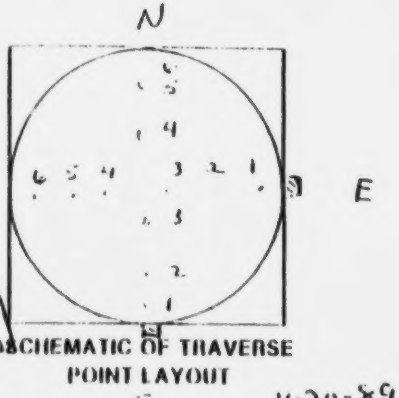
73
[illegible]

FIELD DATA

RUN NO 02
PROJECT NO 9102-57-20
PLANT TWI #4, Sauget, Illinois
DATE 11-18-89 -19-20
SAMPLING LOCATION after to the S.D.A
SAMPLE TYPE MM5 - Metals
OPERATOR Frank Grunwald
FILTER NO 139
RECORD DATA EVERY 5 MIN
UMBILICAL/SAMPLE HOOKUP UH-1

PROBE NO W.C.-10-21 FG
PROBE LENGTH AND TYPE 10', teflon M5
SAMPLE BOX NO 10196
METER BOX NO 10
TEMP CONTROLLER NO Y-0768
TEMP METER NO 7517
THERMOCOUPLE I.D. NO TC.-WC-10-21 FG
UMBILICAL CORD I.D. NO U-25-2
UMBILICAL CORD I.D. NO H.L.-2
NOZZLE NO W-1

NOZZLE DIA .317
ASSUMED MOISTURE % 39.4
METER ΔH@ 1.73
METER CORRECTION .99
PITOT NO P W.C.-21 FG
PITOT COEFFICIENT .84
BAROMETRIC PRESSURE 29.95 | W 29.79
SITE TO BARO. ELEVATION (ft) 60
CORRECTED B.P. (0.1 in./100 ft) 29.89 | 29.73
STATIC PRESSURE -1.5 | 18 | 19



SCHEMATIC OF TRAVERSE POINT LAYOUT

11-20-89
29.51
60
29.45

PITOT LEAK CHECK ≥ 3" H₂O

	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)	1105	1382	1624	1557	0927	
PASS/FAIL		PASS		PASS		

PITOT LEAK CHECK ≥ 3" H₂O

	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)						
PASS/FAIL						

SAMPLE TRAIN LEAK CHECKS

	INITIAL	FINAL	INITIAL	FINAL	INITIAL
TIME (24 hr)	1100	1326	0951		1418
VACUUM, in. Hg	≥ 15"	3.5	≥ 15"		≥ 15"
CFM	.007	.009	.014		.008
VOLUMES					
FINAL		~~128.368~~	128.462	128.979	
INITIAL		~~110.~~ FG	128.368	127.510	
DIFFERENCE			.094	1.469	

Barometric
29.76

SAMPLE TRAIN LEAK CHECKS

	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)		.005		1150	1359
VACUUM, in. Hg		≥15"		≥15"	3.2
CFM		0922		.011	.010
VOLUMES					
FINAL	129.542		129.918		
INITIAL	128.979		129.542		
DIFFERENCE	.563		.376		

INITIAL VOLUME 110.836
FINAL VOLUME 193.136
LEAK CHECK VOLUME 4.577
ADJUSTED FINAL VOLUME 188.559

COMMENTS Further leak checks on following page.

FG
12/2/89

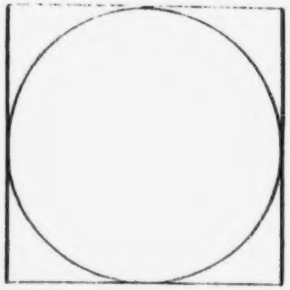
Revision 11/10/86

FIELD DATA

RUN NO 02 - CONT.
PROJECT NO 9102-5720
PLANT TWI # 4, Sauget, ILL.
DATE 11-20-89
SAMPLING LOCATION inlet to S.D.A.
SAMPLE TYPE MM5 = Metals
OPERATOR Frank Grommsen
FILTER NO
RECORD DATA EVERY ____ MIN
UMBILICAL/SAMPLE HOOKUP

PROBE NO
PROBE LENGTH AND TYPE
SAMPLE BOX NO
METER BOX NO
TEMP CONTROLLER NO
TEMP METER NO
THERMOCOUPLE I.D. NO
UMBILICAL CORD I.D. NO
UMBILICAL CORD I.D. NO
NOZZLE NO

NOZZLE DIA
ASSUMED MOISTURE %
METER ΔH@
METER CORRECTION
PITOT NO
PITOT COEFFICIENT
BAROMETRIC PRESSURE
SITE TO BARO ELEVATION (ft)
CORRECTED B.P. (0.1 in / 100 ft)
STATIC PRESSURE



SCHEMATIC OF TRAVERSE POINT LAYOUT

PITOT LEAK CHECK ≥ 3" H_2O

	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)						
PASS/FAIL						

PITOT LEAK CHECK ≥ 3" H_2O

	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)						
PASS/FAIL						

SAMPLE TRAIN LEAK CHECKS

	INITIAL	FINAL	INITIAL	FINAL	INITIAL
TIME (24 hr)	1420	1550			
VACUUM, in. Hg	≥ 15"	20.5	≥ 15"		≥ 15"
CFM	.004	006			
VOLUMES					
FINAL		130.176		153.211	
INITIAL		129.918		151.414	
DIFFERENCE		.258		1.797	

SAMPLE TRAIN LEAK CHECKS

	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)					
VACUUM, in. Hg		≥ 15"		≥ 15"	
CFM					
VOLUMES					
FINAL					
INITIAL					
DIFFERENCE					

INITIAL VOLUME
FINAL VOLUME
LEAK CHECK VOLUME
ADJUSTED FINAL VOLUME

FS
12/2/89

COMMENTS

Revision 11/18/86

RUN NO. 02
DATE 11-18-89 -19-20-

SAMPLING LOCATION inlet to the spray dryer absorber 1 of 1
PROJECT NO. 9102-57-20
OPERATOR Frank Caramano

Start
1202:40
1204:40
Stop
1310:40
Start

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24-hr)	GAS METER READING (V_m), ft³ INITIAL 112.836 DESIRED	ACTUAL	VELOCITY HEAD (Δp_s), in H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H_2O DESIRED	ACTUAL	STACK TEMP (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m_{in}}$), °F	OUTLET ($T_{m_{out}}$), °F	PUMP VAC., in. Hg	IMPINGER TEMP., °F	SAMPLE BOX TEMP., °F	PROBE TEMP., °F	FILTER TEMP., °F	[illegible]	[illegible]	O2 Meter
	0	1235																
S-6	5	1240	114.05	114.13	.71	1.36	1.50	836	67	64	1.0	40	236	245	231	242		
6	10	1245	117.14	117.20	.63	1.23	1.30	828	79	68	.5	39	233	257	241	255		8.9
5	15	1250	120.45	120.34	.71	1.39	1.40	839	89	72	1.5	41	230	239	242			
5	20	1255	123.98	123.70	.80	1.57	1.66	842	92	76	2.2	43	223	246	241			7.6 Down
4	25	1300	127.53	127.51	.83	1.63	1.80	850	94	79	3.1	45	227	241	241		115	7.6 1301:40
4	30	13[illegible] ~~1305~~	13	133.48	.83	1.63	1.80	850	93	81	3.2	46	229	244	242		125	
3	35	1312	137.01	137.01	.81	1.56	1.60	872	83	83	1.8	55	250	242	221			DOWN 1335
3	40	1329	140.42	140.33	.75	1.45	1.50	872	86	84	1.8	55	251	244	231			START 1327
2	45	1339	143.48	143.48	.6	1.16	1.30	872	90	85	1.0	56	252	231	235			11.4
2	50	1344	146.56	146.56	.6	1.16	1.3	872	94	87	1.0	57	251	243	232		125	10.3
1	55	1349	148.97	149.09	.36	.71	.8	848	95	87	.5	58	251	236	239			11.5
1	60	1354	151.414	151.439	.36	.73	.8	820	95	89	.5	57	253	240	242			11.5
C	0	1440																
E-6	5	1445	156.50	156.47	.69	1.34	1.5	858	86	85	2.2	57	251	240	238			12.2
6	10	1450	159.90	159.79	.73	1.42	1.6	866	90	88	2.9	57	253	270	243			7.0
5	15	1455	163.64	163.48	.88	1.72	1.9	873	95	89	3.8	56	253	235	244			7.6
5	20	1500	167.31	167.04	.84	1.65	1.9	870	98	91	4.0	53	254	251	244			11.5
4	25	1505	170.78	170.46	.74	1.46	1.9	865	101	93	4.1	52	253	218	249			9.1
4	30	1510	174.55	174.25	.88	1.73	2.0	878	101	94	5.3	49	252	253	252			13.2
3	35	1523	177.92	177.90	.70	1.39	2.0	855	95	94	5.3	49	251	207	249			12.3
3	40	1528	181.19	181.42	.66	1.30	1.8	865	97	94	5.9	50	250	208	248			10.6
2	45	1533	184.34	184.34	.61	1.21	1.3	865	99	94	6.1	51	250	209	247			3.3
2	50	1538	187.44	187.42	.59	1.17	1.3	861	99	95	7.6	52	251	218	246			7.0
1	55	1543	190.86	190.52	.71	1.42	1.5	848	98	94	19.5	53	250	229	245			8.0
1	60	1548	193.275	193.136	.36	.71	1.0	866	99	94	17.2	56	250	236	245			4.7

510 Down
1519

COMMENTS A-1329
B-1334

P.B.
12/3/89

15

Run No. 2 Date 11 / 20 / 89
Project No. 9304L-06-32 Plant TWI Div. of CWM
Recovery Person T. Hartman

METALS - SDA INLET

SAMPLE BOX NO. 10196

FILTER NO. 134 136 Color/condition Light brown
_3218 2224

IMP. 1	IMP. 2	IMP.3	IMP. 4	IMP. 5	IMP. 6
MGBS/2L ~~Dry~~ 300 ml H2O	MGBS HNO3/H2O2 100 ml	GBS HNO3/H2O2 100 ml	MGBS KMnO4 100 ml	Mod KMnO4 100 mL	Mod Silica

	FINAL	INITIAL	DIFFERENCE
IMP. 1	2388.9 g	1731.3 g	657.6 g
IMP. 2	699.8	544.5	99.3
IMP. 3	640.8	620.2	20.6
IMP. 4	640.4	635.6	4.8
IMP. 5	613.7	609.5	4.2
IMP. 6	724.1	707.5	16.6 × Blue 20
		TOTAL	[803.1] [illegible]

SAMPLE BOTTLES

	Condensate HNO3/H2O2 _2219	KMnO4 _2220	PROBE RINSE ACETONE _2216	PROBE RINSE HNO3 _2217	Dry Catch 2223
FINAL	2700.0 g	600.7	578.5	505.5	
INITIAL	1245.0 g	254.8	253.4	256.0	
DIFFERENCE	[1455.0 g]	[345.9]	[324.6]	[249.5]	
LEVEL MARKED	____	____	____	____	

COMMENTS: 38.8 mls of condensate pulled over into Filter
[redacted] 2222 Flt Acetone Initial wt 254.7 Final 464.4
2221 15 ml aliquot of sample # 2219
2223 Dry Catch

VOLUMES

MOISTURE VOLUME 803.1
CONDENSATE/HNO3/H2O2 1455.0
KMnO4 345.9
PROBE RINSE ACETONE 324.6
PROBE RINSE HNO3 249.5

Reviewed by ____ Date ___ / ___ /89
PS 12/2/89

MIDWEST RESEARCH INSTITUTE

Run Number C3 Project Number 9102-57-20

Date 11-21-89

Plant TWI #4, Sauget, Illinois

Sampling Location inlet to the S.D.A.

FIELD CREW

Crew Chief	FG ~~Dick Cobb~~ Don March
Testing Engineer	Frank Grammer
Assistant Testing Engineer	Don March
Process Engineer	Paul Grossman
Other	

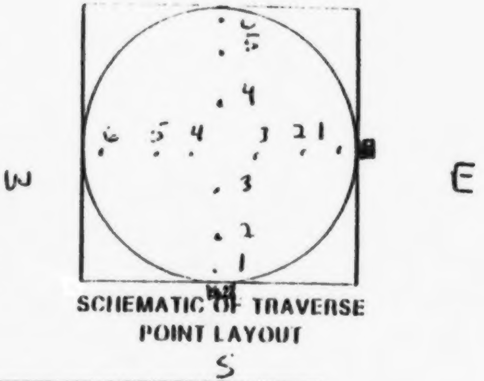
DJ
12/3/89

FIELD DATA

RUN NO ~~9102-57-20~~ FN 03
PROJECT NO 9102-57-20
PLANT T.W.I. #4, Sauget, Illinois
DATE 11-21-89
SAMPLING LOCATION inlet to the S.D.A.
SAMPLE TYPE MM5 - metals
OPERATOR FRANK GRAMMER
FILTER NO 132
RECORD DATA EVERY 5 MIN
UMBILICAL/SAMPLE HOOKUP UH-1

PROBE NO W.C. - 1-10
PROBE LENGTH AND TYPE 10' - teflon, M5
SAMPLE BOX NO 10196
METER BOX NO 10
TEMP CONTROLLER NO Y-0768
TEMP METER NO 9517
THERMOCOUPLE ID NO W.C. 1-10
UMBILICAL CORD ID NO U-25-2
UMBILICAL CORD ID NO H.L.-2
NOZZLE NO W-1

NOZZLE DIA .317
ASSUMED MOISTURE % 35
METER ΔH@ 1.78
METER CORRECTION .99
PITOT NO P-W.C.-1
PITOT COEFFICIENT .84
BAROMETRIC PRESSURE 29.73
SITE TO BARO ELEVATION (ft) 60
CORRECTED B.P. (0.1 in/100 ft) 29.67
STATIC PRESSURE -1.5



SCHEMATIC OF TRAVERSE POINT LAYOUT

PITOT LEAK CHECK ≥ 3" H_2O

	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)	1042	1430				
PASS/FAIL		PASS				

PITOT LEAK CHECK ≥ 3" H_2O

	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)						
PASS/FAIL						

SAMPLE TRAIN LEAK CHECKS

	INITIAL	FINAL	INITIAL	FINAL	INITIAL
TIME (24 hr)	1038	1251	1307	1425	
VACUUM, in. Hg	≥ 15"	2.7	≥ 15"	10"	≥ 15"
CFM	.004	.003	.011	.002	
VOLUMES					
FINAL		230.864			
INITIAL		230.322			
DIFFERENCE		.542			

SAMPLE TRAIN LEAK CHECKS

	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)					
VACUUM, in. Hg		≥ 15"		≥ 15"	
CFM					
VOLUMES					
FINAL					
INITIAL					
DIFFERENCE					

INITIAL VOLUME 194.376
FINAL VOLUME 372.175
LEAK CHECK VOLUME .542
ADJUSTED FINAL VOLUME 271.633

COMMENTS

TB
12/7/89

Revision 11/18/86

RUN NO 03
DATE 11-21-89

SAMPLING LOCATION inlet to the S.O.A.
PROJECT NO 9102-57-20

P. 1 of 1
OPERATOR Frank Grammer

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24-hr)	GAS METER READING (V_m), ft³ INITIAL 194.376 DESIRED	GAS METER READING ACTUAL	VELOCITY HEAD (Δp_s), in H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H_2O DESIRED	ORIFICE PRESSURE DIFFERENTIAL ACTUAL	STACK TEMP (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m_{in}}$), °F	DRY GAS METER TEMPERATURE OUTLET ($T_{m_{out}}$), °F	PUMP VAC., in. Hg	IMPINGER TEMP., °F	SAMPLE BOX TEMP., °F	PROBE TEMP., °F	FILTER TEMP., °F	CO Meter
	0	1133														
E - 6	5	1138	FG 194 197.31	197.62	.57	1.17	1.2	870	56	57	0	48	259	217	237	
6	10	1143	200.44	200.44	.58	1.22	1.2	861	69	62	0	47	255	217	241	20.1
5	15	1148	203.71	203.56	.65	1.37	1.4	870	74	64	0	48	256	222	258	NA
5	20	1153	206.92	206.67	.62	1.32	1.4	870	79	66	.2	49	265	231	271	
4	25	1158	210.15	210.01	.62	1.33	1.5	863	81	63	1.0	49	231	223	260	
4	30	1203	213.63	213.63	.71	1.53	2.1	863	84	71	2.2	48	242	218	261	
3	35	1220	216.94	217.86	.67	1.41	1.8	875	69	63	2.1	44	239	231	242	7.6
3	40	1226	220.22	220.19	.65	1.37	1.8	875	74	70	2.4	45	231	236	254	7.8
2	45	1230	223.09	223.70	.48	1.04	1.1	847	79	71	1.8	47	240	240	255	6.5
2	50	1235	225.97	226.48	.49	1.06	1.0	851	78	71	1.8	47	237	242	252	10.4
1	55	1240	228.20	228.50	.29	.63	.5	840	77	71	.2	45	232	243	246	7.8
1	60	1245	230.322	230.421	.26	.59	.5	834	75	71	.2	45	231	231	242	11.1
0	0	1319	230.864	" → FG "	~~.66~~	1.3		866	65	66 FG						
S - 6	5	1324	234.14	234.22	.66	1.39	1.5	866	65	66	2.4	40	251	237	231	10.6
6	10	1329	237.44	237.44	.66	1.40	1.5	864	70	67	2.8	42	231	228	233	12.1
5	15	1334	240.84	240.64	.7	1.48	1.6	878	77	69	3.2	43	252	237	244	9.7
5	20	1339	244.50	244.34	.79	1.69	2.0	867	81	71	4.2	42	248	236	246	9.5
4	25	1344	247.92	247.99	.7	1.48	1.9	884	82	72	4.6	44	251	240	244	11.3
4	30	1349	251.91	252.09	.95	2.02	2.5	877	80	71	6.1	44	252	240	251	10.2
3	35	1354	255.80	254.18	.83	1.90	2.4	865	86	73	6.5	44	252	243	251	11.2
3	40	1359	259.76	259.76	.92	1.98	2.3	869	85	73	6.8	43	253	241	253	8.6
2	45	1404	263.48	264.01	.8	1.13	2.0	862	87	74	6.2	43	252	250	254	10.6
2	50	1409	266.96	267.35	.7	1.52	1.5	864	89	75	5.2	42	253	251	254	9.3
1	55	1414	269.49	269.95	.36	.8	.8	833	91	77	3.2	42	252	254	254	8.4
1	60	1419	271.919	272.175	.33	.73	.6	833	84	79	2.9	41	253	227	253	9.7

DOWN
1203
1215
start

COMMENTS

P.8
12/3/89

15

Run No. 3
Date 11 / 21 / 89
Project No. 9304L-06-32
Plant TWI Div. of CWM
Recovery Person T. Hartman

METALS - SDA INLET

SAMPLE BOX NO. ~~[illegible]~~ 10146

FILTER NO. ~~126~~ TH 132 Color/condition ~~[illegible]~~ Light Brown / Heavy loading
3218

IMP. 1	IMP. 2	IMP.3	IMP. 4	IMP. 5	IMP. 6
mGBS/2L	mGBS	GBS	mGBS	Mod	Mod
~~Dry~~ 300 ml H2O	HNO3/H2O2	HNO3/H2O2	KMnO4	KMnO4	Silica
	100 ml	100 ml	100 ml	100 mL	

	FINAL	INITIAL	DIFFERENCE
IMP. 1	2511.9 g	Dim ~~1574.8~~ 1739.6 g	772.3 g
IMP. 2	223.8	622.4	101.4
IMP. 3	633.5	618.8	14.7
IMP. 4	633.2	TH ~~615.2~~ 629.1	4.1
IMP. 5	609.8	607.6	2.2
IMP. 6	694.2	681.1	13.1 × Blue ≃ 1/0
TOTAL			~~1002.8~~ 907.8 pc

SAMPLE BOTTLES

	Condensate HNO3/H2O2 3219	KMnO4 3220	PROBE RINSE ACETONE 3216	PROBE RINSE HNO3 3217	Dry Catch 3223
FINAL	2757.5 g	590.1	387.8	530.5	
INITIAL	1250.7 g	255.7	254.5	254.2	
DIFFERENCE	[1506.8]	[334.4]	[133.3]	[276.3]	
LEVEL MARKED					

COMMENTS: 3221 - 15 ml condensate aliquot
3222 - FH Acetone Initial wt 256.3 Final wt 581.1

VOLUMES

MOISTURE VOLUME 907.8
PROBE RINSE ACETONE 133.3
CONDENSATE/HNO3/H2O2 1506.8
PROBE RINSE HNO3 276.3
KMnO4 334.4

Reviewed by ____ Date ___ / ___ /89
FG 12/7/89

APPENDIX I

CALIBRATION DATA FOR SAMPLING EQUIPMENT

REQUEST FOR POSTTEST CALIBRATION

Test Location TWI - Sauget, Ill.

Test Dates 11-21, 20, 18, 17, 16, -89

Crew Chief Dan March

Project No. 9102-57-20

RAC Console No.	Avg. ΔH	Maximum Vacuum
10	1.67	19.5

Stack T.C. No.	Pyrometer No.	Avg. Stack Temperature
W.C.-1-10	9517	FG ~~862~~ 860
W.C.-2-10	9517	836

Barometer No. X-4029

Pyrometer-Potentiometer No.:

9517

Dry Gas Meter No.	Avg. Flow Rate ACFM

Sample Nozzle No. W-1,

POST-TEST CALIBRATION SUMMARY
FOR METHOD 5

Plant TWI, Sauget Ill. SDA

Calibration Dates 12-89 1-90

Field Dates 11-89

Calibration By Frank Grammer

Console No.	Gas Meter - Y Calib.		Post-Test ± 5% of Pretest?	DGM Thermometers ± 10.8° F of Scale?
	Pretest	Post-Test		
10	1.024	1.035	Yes	Yes

Stack T.C. No.	Avg. Stack Temp. °F	Calibration Temp. °F	Error °R	Post-Test ± 1.5% of Calib. Std.?
W.C.-2-10	860	60, 350, 527, 32	~~4.3~~ .7, 4.7, 17, .4	.13, .58, 1.75, .08
W.C.-~~2~~ 1.64 10	836	60, 345, 531, 32	.6, 8.5, 21, .2	.115, 1.05, 2.17, .04

Barometer No.	Calibration Readings, In. Hg		Post-Test ± 0.1 In. of Std. Baro.?
	Field Baro.	Std. Baro.	
X-4029	29.03	29.03	Yes 0.00

Pitot No. P.-W C.-1

Vacuum Pumps:

Type	No.	Type	No.

Rotometers:

Type	No.	Type	No.

List Other Equipment to be Calibrated:

inlet – UH-1, U-25-2, H.L. #2, S.B.-#10196, T.C.- Y-0768, UH-6, S.B.-1119C

Note Special Instructions or Equipment Problems:

TYPE S PITOT TUBE INSPECTION DATA FORM

PITOT NO. W.C.-2 DATE 12-21-89 INSPECTOR Frank Grammer

Pitot tube assembly level ? X YES; ____ NO

Pitot tube openings damaged ? X YES(comment); ____ NO

α^1 = 1 °(<10°); α^2 = 1 °(<10°)

$\beta 1$ = 2 °(<5°); $\beta 2$ = 0 °(<5°)

γ = 0 °; T = 0 °; A = .713 cm [✓ in.]

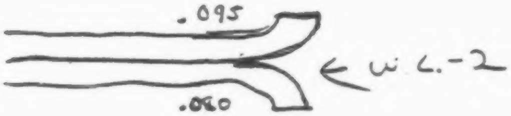
Z = A sin γ = ________ cm (in.) <0.32 cm [✓ <0.125 in.]

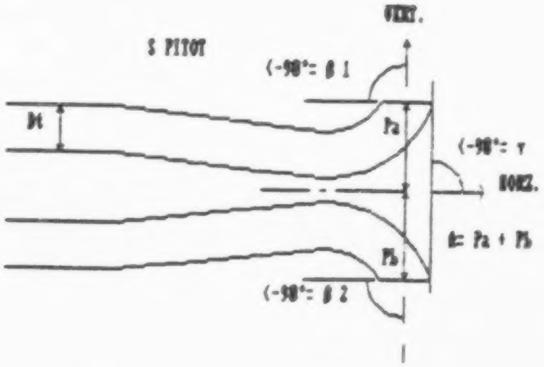
W = A sin θ = ________ cm (in.) <0.08 cm [✓ <0.0313 in.]

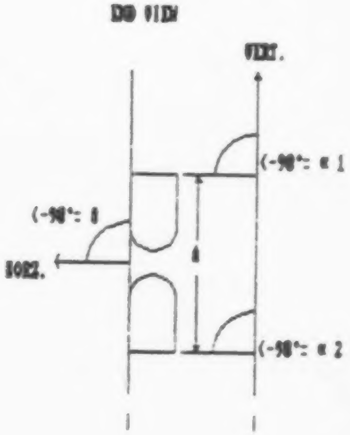
PA = ________ cm [✓ in.] PB = ________ cm [✓ in.]

Dt = .255 cm [✓ in.]

COMMENTS one tip was bent, I straightened it and proceeded with the inspection. The tip was bent ~~during~~ while being moved after the last test was completed.




S PITOT
VERT.
(<90°= β 1
Dt
Pa
(<90°= γ
HORZ.
Pb
A= Pa + Pb
(<90°= β 2


END VIEW
VERT.
(<90°= α 1
(<90°= θ
HORZ.
A
(<90°= α 2

TYPE S PITOT TUBE INSPECTION DATA FORM

PITOT NO. W.C.-$\overset{Fa}{2}$1 DATE 12-22-89 INSPECTOR Frank Grammer

Pitot tube assembly level ? ✓ YES; _____ NO

Pitot tube openings damaged ? _____ YES(comment); ✓ NO

α^1 = 4 °(<10°); α^2 = 1 °(<10°)

$\beta 1$ = 2.5 °(<5°); $\beta 2$ = 2.5 °(<5°)

γ = 0 °; T = 0 °; A = .747 cm [✓ in.]

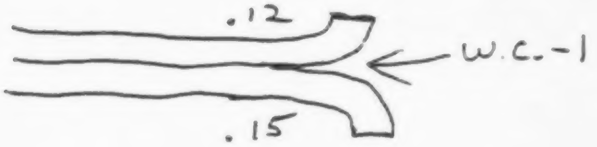
Z = A sin γ = ______ cm [✓ in.] <0.32 cm (<0.125 [✓ in.])

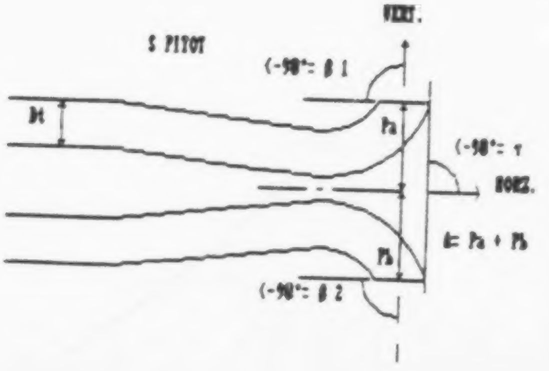
W = A sin θ = ______ cm [✓ in.] <0.08 cm (<0.0313 [✓ in.])

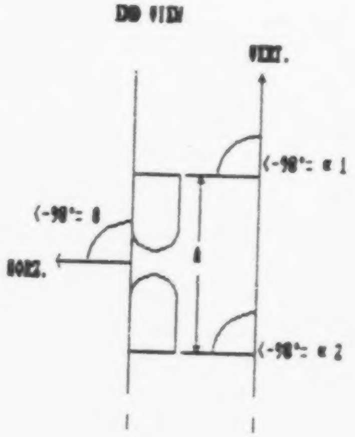
PA = ______ cm [✓ in.] PB = ______ cm [✓ in.]

Dt = .250 cm [✓ in.]

COMMENTS____




S PITOT
VERT.
(-90°= β 1
Dt
PA
(-90°= γ
HORZ.
A= PA + PB
PB
(-90°= β 2


END VIEW
VERT.
(-90°= α 1
(-90°= θ
HORZ.
A
(-90°= α 2

STACK TEMPERATURE METER CALIBRATION DATA FORM

Project no. 9102-57-20

Date 12-22-89

☐ Potentiometer

☒ Pyrometer number 9517

Ambient temperature 70 °F

Barometric pressure 30.07 in. Hg

Calibrator Frank Grammer

Reference: mercury-in-glass ASTM 63F/68F/69F

Average stack temp. ______ °F

Serial no. 1979299/1:244/566093(JENA 2954)

Temperature reference type/SN	Source[b] (specify)	Reference thermometer temperature, °F	Thermocouple potentiometer temperature, °F	Temperature difference,[c] %
W.C.-1	ambient H2O bath	60.6	60.0	
W.C-2	" "	60.7	60.0	
W.C.-1	hot oil bath	353.5	345.0	
W.C-2	" "	345.3	350.0	
W.C.-1	" "			
W.C-2	" "			

[b] Type of calibration system used.

[c] $$\left[\frac{(\text{ref temp, }^\circ\text{F} + 460) - (\text{test thermom temp, }^\circ\text{F} + 460)}{\text{ref temp, }^\circ\text{F} + 460}\right] 100 \leq 1.5\%$$

STACK TEMPERATURE METER CALIBRATION DATA FORM

Project no. 9304-31-03

Date 3-6-89

☐ Potentiometer
☒ Pyrometer number 9517

Ambient temperature 68° °F

Barometric pressure 29.4 in. Hg

Calibrator FG

Reference: mercury-in-glass ASTM 68F

Average stack temp. 390 °F

Serial no. 613947

Temperature reference type/SN	Source[b] (specify)	Reference thermometer temperature, °F	Thermocouple potentiometer temperature, °F	Temperature difference,[c] %
2-42	Hot Oil Bath	380	387	.83

[b] Type of calibration system used.

[c] $\left[\frac{(\text{ref temp, °F} + 460) - (\text{test thermom temp, °F} + 460)}{\text{ref temp, °F} + 460}\right] 100 \leq 1.5\%$

NOZZLE CALIBRATION DATA FORM

Date 11-7-89 Calibrated by RCS

Nozzle identification number	Nozzle Diameter[a]			ΔD,[b] mm (in.)	D_{avg}[c]
	D_1, mm (in.)	D_2, mm (in.)	D_3, mm (in.)		
Q W-1	(.318)	(.317)	(.317)	(.001)	.317
Q W-2	(.317)	(.318)	(.316)	(.002)	.317
Q W-3	(.314)	(.315)	(.315)	(.001)	.315
Q XW-1	(.240)	(.239)	(.239)	(.001)	.239
Q 4-3	(.241)	(.242)	(.241)	(.001)	.241
Q 6-1	(.207)	(.207)	(.208)	(.001)	.207
Q 6-2	(.311)	(.312)	(.311)	(.001)	.311
Q 6-3	(.358)	(.358)	(.358)	Zero	.358
Q 6-4	(.202)	(.202)	(.202)	Zero	.202
Q 6-5	(.318)	(.318)	(.318)	Zero	.318
Q 6-6	(.273)	(.273)	(.272)	(.001)	.273
Q 6-7	(.237)	(.237)	(.236)	(.001)	.237
Q 6-8	(.366)	(.365)	(.366)	(.001)	.366

where:

[a] $D_{1,2,3,}$ = three different nozzles diameters, mm (in.); each diameter must be within (0.025 mm) 0.001 in.

[b] ΔD = maximum difference between any two diameters, mm (in.), $\Delta D \leq$ (0.10 mm) 0.004 in.

[c] D_{avg} = average of D_1, D_2, and D_3.

NOZZLE CALIBRATION DATA FORM

Date 1-16-90 Calibrated by Frank Grammer

Nozzle identification number	Nozzle Diameter[a]			ΔD,[b] mm (in.)	D_{avg}[c]
	D_1, mm (in.)	D_2, mm (in.)	D_3, mm (in.)		
W-1	.318	.317	.317	.001	.317

where:

[a] $D_{1,2,3,}$ = three different nozzles diameters, mm (in.); each diameter must be within (0.025 mm) 0.001 in.

[b] ΔD = maximum difference between any two diameters, mm (in.), $\Delta D \leq$(0.10 mm) 0.004 in.

[c] D_{avg} = average of D_1, D_2, and D_3.

RAC CONSOLE POSTTEST CHECKLIST

Date 1-10-90 Console No. 10 Operator Baker

Place a check (in black ink) in the space provided after the required maintenance is performed.

1. ✓ Timer gear inspection.
2. ✓ Clean pump.
3. ✓ Clean muffler jar.
4. ✓ Inspect oiler jar.
5. ✓ Calibrate thermometers. (Tolerance = 2 deg. F) Ref. Temp. = 58.7 Inlet Temp. = 58.6 Outlet Temp. = 58.6.
6. ✓ Leak check meter system.
7. ✓ Leak check remaining manometer.
8. ✓ Vacuum check. Leak check at maximum vacuum attained during test. Leak rate should be zero.
9. ✓ Indicator lights.
10. ✓ Buzzer.
11. ✓ Thermocouples.
12. ✓ Fan.
13. ✓ Heater.
14. ✓ Probe temperature potentiometer.

If any of the above items were replaced or repaired please document that information here:

BAROMETER CALIBRATION
Data Sheet

Field Barometer No. X-4029 Date 11-7-89

Project No. ________ Initial BCS

Location ________

Reference Barometer No. X-4857

Ref. Barometer Reading 29.23

Ref. Barometer Temp. (F) 80

Temperature Correction for Hg Reference Barometer

Reading X (1 - Correction Factor) = Corrected Reading

29.23 ~~024~~ X (1 - .004642) = 29.09 ~~28.23~~

Corrected Hg Reference Barometer Reading = ________

Field Barometer Reading 29.06

Error of Field Barometer

-0.03 Inches of Hg

Allowed Error = ± 0.10 Inches of Hg

BAROMETER CALIBRATION
Data Sheet

Field Barometer No. X-4029 Date 1-17-90

Project No. 9304/9102 Initial Frank Grammer

Location Sauget, Ill.

Reference Barometer No. X-4857

Ref. Barometer Reading 29.14

Ref. Barometer Temp. (F) 72

Temperature Correction for Hg Reference Barometer

Reading X (1 - Correction Factor) = Corrected Reading

29.14 x (1 - .003922) = 29.03

Corrected Hg Reference Barometer Reading = 29.03

Field Barometer Reading 29.63

Error of Field Barometer

0.00 Inches of Hg

Allowed Error = ± 0.10 Inches of Hg

Name: Ted Hartman Calibration Std/Capacity NA Phone: 753-7600

Date 1-15-90 Train ID NA DGM Cal. Factor, Y 1.03 Orifice No. A5, A6, A8

Type of Meter Box M5 Type of Pump Gast Vacuum

			Run Number		
		Example	1 A8	2 A6	3 A5
WTM or Calibration Standard					
Final reading	ft^3	10.005			
Initial reading	ft^3	0			
Difference, V_w	ft^3	10.005			
Temperature, t_w	°F	74			
DGM					
Final reading	ft^3	966.461	396.837	391.487	405.680
Initial reading	ft^3	946.602	391.800	354.500	397.400
Difference, V_m	ft^3	9.859	5.037	6.977	8.280
Inlet/Outlet temperatures					
Initial	°F	108 / 88	89 / 87	89 / 85	92 / 88
After 5 minutes		110 / 88	89 / 88	91 / 86	94 / 88
After 10 minutes		111 / 88	90 / 88	92 / 87	95 / 89
Final		112 / 89	91 / 87	92 / 87	96 / 89
Avg. temperature, t_d	°F	99.3	88.6	88.6	91.3
Time, Θ	min	15.0	15.00	15.00	15.00
Orifice man. rdg., ΔH	in. H_2O	1.35	0.35	0.68	0.97
Bar. pressure, P_{bar}	in. Hg	29.75	29.39	29.39	29.39
Room temperature, t_i	°F	74	78.3	78.3	78.3
Pump vacuum	in. Hg	18.8	19.0	19.0	19.0
$V_{w(std)}$	ft^3	9.8324			
$V_{m(std)}'$	ft^3	9.2815			
DGM cal. factor, Y_c		1.0593			
K' factor		0.5092			

Figure 2. Data sheet.

```
Console Calibration
Project              93040632     Barometric pressure 29.3900
Date                 1-16-90      Orifice number      A6
Operator             K.BAKER      Orifice K factor      .3599
Console Number            10      Previous Y factor   ? 1.024

                     Run 1               Run 2       Run 3

Final DGM Volume      391.487                391.487 391.487
Inital DGM Volume      384.51                 384.51  384.51
Net DGM Volume (Vm)     6.977       6.97700000000003   6.977

Ave. In/Out DGM Temp.    88.6                   88.6    88.6
Time, min.                 15                     15      15
Orifice DH, in. H2O       .68                    .68     .68
Baro. Press., in. Hg    29.39                  29.39   29.39
Room temp., Deg. F       78.3                   78.3    78.3
Pump Vacuum, in. Hg        19                     19      19


Vcr (std)            6.838494       6.83849449851759 6.838494
Vm (std)             6.604642       6.60464236821002 6.604642
Y Factor             1.035407        1.0354072358911 1.035407

Average Y            1.035407

This calibration conducted after repair from being dropped
```

```
Console Calibration
Project              93040632     Barometric pressure 29.3900


Date                 1-16-90      Orifice number       A5
Operator             K.BAKER      Orifice K factor       .4255
Console Number            10      Previous Y factor    ? 1.024

                     Run 1                   Run 2      Run 3

Final DGM Volume      405.68                405.68     405.68
Inital DGM Volume      397.4                 397.4      397.4
Net DGM Volume (Vm)     8.28      8.28000000000003       8.28

Ave. In/Out DGM Temp.   88.6                  88.6       88.6
Time, min.                15                    15         15
Orifice DH, in. H2O      .97                   .97        .97
Baro. Press., in. Hg   29.39                 29.39      29.39
Room temp., Deg. F      78.3                  78.3       78.3
Pump Vacuum, in. Hg       19                    19         19


Vcr (std)            8.084966     8.08496640488812 8.084966
Vm (std)             7.843779     7.84377933949521 7.843779
Y Factor             1.030749     1.03074883356018 1.030749

Average Y            1.030749

This calibration conducted after repair from being dropped
```

Console Calibration

Project	8862	Barometric pressure	29.7000
Date	10-17-89	Orifice number	A6
Operator	Barnes	Orifice K factor	0.3599
Console Number	10	Previous Y factor	1.0400

	Run 1	Run 2	Run 3
Final DGM Volume	273.965	281.23	288.497
Inital DGM Volume	266.7	273.965	281.23
Net DGM Volume (Vm)	7.265	7.265	7.267
Ave. In/Out DGM Temp.	105.2	105.8	106.5
Time, min.	15	15	15
Orifice DH, in. H20	0.68	0.68	0.68
Baro. Press., in. Hg	29.7	29.7	28.8
Room temp., Deg. F	80.4	80.6	78
Pump Vacuum, in. Hg	19	19	19
Vcr (std)	6.897185	6.8959091991	6.703080
Vm (std)	6.745575	6.7384223224	6.528293
Y Factor	1.022475	1.0233714762	1.026773
Average Y	1.024206		

```
Console Calibration
Project                  93040632     Barometric pressure 29.3900
Date                      11-28-89    Orifice number      A8
Operator                 K.BAKER      Orifice K factor        .2619
Console Number                10      Previous Y factor  ? 1.024


                         Run 1                  Run 2        Run 3

Final DGM Volume          396.837               396.837  396.837
Inital DGM Volume           391.8                 391.8    391.8
Net DGM Volume (Vm)         5.037      5.03699999999998    5.037


Ave. In/Out DGM Temp.        88.6                  88.6     88.6
Time, min.                     15                    15       15
Orifice DH, in. H2O           .35                   .35      .35
Baro. Press., in. Hg        29.39                 29.39    29.39
Room temp., Deg. F           78.3                  78.3     78.3
Pump Vacuum, in. Hg            19                    19       19


Vcr (std)                4.976197      4.97619706645393 4.976197
Vm (std)                 4.764249      4.76424884260468 4.764249
Y Factor                 1.044487      1.04448722786138 1.044487

Average Y                1.044487

This calibration conducted after repair from being dropped
```

UMBILICAL HOOKUP CALIBRATION DATA FORM

Date 11-29-89 Project No. 9304063 Calibrator DW

Ambient Temp. 77 F Barometric Pressure 29.54 in. Hg

Reference: mercury-in-glass 63 ASTM Serial No. 1979299

Umbilcal Hookup No.	Leak Check & Check Valve (pass/nopass)	Thermocouple or Thermometer ID. No.	Source (specify [b])	Reference Thermometer Temperature deg F	Thermocouple or Thermometer Temp (F)	Temperature difference deg. F (± 2 deg)
UH-6	PASS	H6	AMBIENT H2O BATH	62.8	(H6) 62	.8
UH-2	PASS	H2	↓	↓	(H2) 62	.8
UH-1	PASS	H1			(H1) 62	.8
UH-9	PASS	H9			(H9) 62	.8

[b] Type of calibration system used

UMBILICAL HOOKUP CALIBRATION DATA FORM

Date 11-6-89 Project No. 9304-0631 Calibrator DW

Ambient Temp. 75 F Barometric Pressure 28.75 in. Hg

Reference: mercury-in-glass 63 oF ASTM Serial No. 1979299

Umbilcal Hookup No.	Leak Check & Check Valve (pass/nopass)	Thermocouple or Thermometer ID. No.	Source (specify[b])	Reference Thermometer Temperature deg F	Thermocouple or Thermometer Temp (F)	Temperature difference deg. F (± 2 deg)
UH-1	PASS	H-1	AMBIENT H2O Bath	63.8	63	0.8
UH-12	PASS	H-12	↓	↓	↓	↓
UH-6	PASS	H-6				
UH-4	PASS	H-4				

[b] Type of calibration system used

STACK TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 12-22-89

Project number 9102-57-20

Ambient temperature 70 °F

Barometric pressure 20.07 in. Hg

Calibrator Frank Grammer

Reference: mercury-in-glass ASTM 63F/68F/69F

Average stack temp. ______ °F

Serial no. 1979299/1244/566093 (Jem# 2954)

Thermocouple number	Source[b] (specify)	Reference thermometer temperature, °F	Thermocouple potentiometer temperature, °F	Temperature difference,[c] %
W.C.- 2	ambient H2O bath	60.7	60.0	.13
W.C.-2	hot oil bath	345.3	350.0	.58
W.C.- 2	" "	510.0	527.0	1.75
W.C.-2	ice bath	32.4	32.0	.08

[b] Type of calibration system used.

[c] $$\left[\frac{(\text{ref temp, °F} + 460) - (\text{test thermom temp, °F} + 460)}{\text{ref temp, °F} + 460}\right] 100 \leq 1.5\%$$

STACK TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 7-15-86 Project number 8649-L8

Ambient temperature 77 °F Barometric pressure 29.17 in. Hg

Calibrator RCS Reference: mercury-in-glass ASTM 69F

Average stack temp. 1700 °F Serial no. 2954

Thermocouple number	Source[b] (specify)	Reference thermometer temperature, °F	Thermocouple potentiometer temperature, °F	Temperature difference,[c] %
T-8 (w.c.-1)	Oil Bath	462	463	0.11%
T-4 (w.c.-2)	Oil Bath	463	465	0.22%

[b] Type of calibration system used.

[c] $$\left[\frac{(\text{ref temp, °F} + 460) - (\text{test thermom temp, °F} + 460)}{\text{ref temp, °F} + 460}\right] 100 \leq 1.5\%$$

STACK TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 12-22-89 Project number 9102-57-20

Ambient temperature 70 °F Barometric pressure 30.07 in. Hg

Calibrator Frank Grammer Reference: mercury-in-glass ASTM 63F/68F/69F

Average stack temp. ______ °F Serial no. 1979299/1244/566093 (JENA 2454)

Thermocouple number	Source[b] (specify)	Reference thermometer temperature, °F	Thermocouple potentiometer temperature, °F	Temperature difference,[c] %
W.C.-1	ambient H2O bath	60.6	60.0	FG ~~1.15~~ .115
W.C.-1	hot oil bath	353.5	345.0	1.05
W.C.-1	" "	510.0	531.0	2.17
W.C.-1	ice bath	32.2	32.0	.04

[b] Type of calibration system used.

[c] $$\left[\frac{(\text{ref temp, °F} + 460) - (\text{test thermom temp, °F} + 460)}{\text{ref temp, °F} + 460}\right] 100 \leq 1.5\%$$